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EFFECTS OF ALCOHOL ON NATURAL RESISTANCE TO THE DWARF TAPEWORM IN MICE¹

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Mice have a strong natural resistance to infection with the dwarf tapeworm, *Hymenolepis nana* var. *fraterna*. Following initial infection it is common for less than five per cent of the eggs to develop into mature cysticercoids in the intestinal villi (Hunninen, 1935; Larsh, 1943b). The underlying mechanism responsible for this resistance is undetermined, but certain factors as age, concurrent infection and splenectomy have been shown to have a favorable or unfavorable influence. The present study was an attempt to gather additional information by determining the influence of alcohol on this resistance. Tests with the drug were performed: (1) to determine the effect on resistance of various concentrations (10 to 45 per cent) given for varying periods of time; (2) to compare the effect on resistance of injections given orally with those given by peritoneum; (3) to learn whether or not alcoholic debilitation is permanent; and (4) to determine the effect on resistance of one intoxicating dose.

Many workers have found large amounts of alcohol detrimental to the process of resistance to many bacterial infections. This is well illustrated by the work of Koch (1885), Doyen (1885) and Thomas (1893) on cholera; of Laitinen (1900) and Goldberg (1901) on anthrax; and of Rubin (1904) and Pickrell (1938) on pneumococcic infections. In short, numerous investigators using many different infecting agents agree that alcohol in large amounts, especially over long periods, has a definitely harmful effect on the natural defenses of many animals. Although the effect of moderate amounts of alcohol is disputed, most workers believe that small quantities (less than 1.5 cc per kilogram) have little or no effect on resistance (Laitinen, 1900; Kruschilin, 1909; Parkinson, 1909). From a review of experimental work, one concludes that the effect of alcohol on the bodily processes involved in resistance depends in large measure on the concentration of the drug and the number of injections given.

METHODS

The mice, of the same strain used in earlier work, were raised *Hymenolepis*-free in this laboratory in an air-conditioned room maintained at 75° F. Ninety-five per cent alcohol was diluted with distilled water to obtain the percentage by volume of the drug needed. When given by way of the gastro-intestinal tract the alcohol was administered into the esophagus through a blunt 18-gauge needle at-

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tached to a one-cubic centimeter syringe. In all cases, the doses were confined in a volume of 0.4 cc. Intraperitoneal injections were given aseptically using a similar syringe and a 27-gauge needle.

In preliminary tests on mice 2-3 months old, it was found that concentrations of 50 per cent or more by mouth were very toxic and the survival rate low, but a high percentage survived doses of 45 per cent given daily for one month. Of those failing to survive, females outnumbered the males two to one. This amount of alcohol produced intoxication (unconsciousness) within ten minutes and stupor lasted two to six hours. It often was necessary to separate animals after being injected to prevent destruction of those that recovered slowly. After recovery most of them showed no noticeable variation from controls in physical appearance or behavior. Others dropped a few grams in weight, developed diarrhea, and the coat lost its natural gloss and became quite ruffled. Concentrations of 40 and 35 per cent given in the same volume to different mice of the same age produced intoxication almost as rapidly as 45 per cent and the animals required about the same length of time to recover. However, 25 per cent alcohol in most cases did not produce narcosis, but the animals staggered about in a stuporous state for an hour or more. Concentrations below 25 per cent given in the volume indicated had no visible effect on most of the animals.

Preliminary tests also were made of young mice given normal saline in place of alcohol once daily for several weeks to determine whether or not the injections alone produced mucosal damage which resulted in a higher percentage development of cysticercoids. After infection the number of parasites was about the same as in untreated controls so the procedure was omitted in the experiments reported below.

The methods of obtaining eggs and calculating doses for infections, of preparing the intestine free of mucus to facilitate cysticercoid counting, and other experimental details can be referred to elsewhere (Hunninen, 1935). As in previous work, all cysticercoid counts were made of animals killed 93 hours after infection. The M₂ strain of the parasite was used, but eggs for infections were not stored as in recent work (Larsh, 1943b).

EXPERIMENTAL RESULTS

1. *The effect on natural resistance of twenty daily injections of 45 per cent alcohol.*—Experimental mice two months old were matched with controls of similar age, sex, and approximate weight. Each of the experimental animals was given by mouth a daily injection of 0.4 cc of 45 per cent alcohol for a period of 20 days. On the basis of the preliminary tests mentioned above, this represented a maximum sublethal amount. Twenty-four hours after the last dose, each of the alcoholic mice and their controls was infected with 900 *Hymenolepis* eggs. The number of cysticercoids counted in each mouse and the calculated percentage development is given in Table 1. The percentages of development for the experimental group ranged from 5.9 to 8.9 (average: 7.4), and for the controls 0.9 to 3.6 (average: 1.9). Thus, the percentages for the alcoholic mice were nearly four times greater than those of the non-alcoholic controls of similar age, sex and approximate weight. The alcohol, therefore, in some way produced definite debilitation which resulted in a lowered resistance to infection.

2. *The effect on natural resistance of 45, 35, 25, and 10 per cent alcohol given to different mice for various periods of time.*—Having shown the detrimental effect

of 20 daily administrations of 45 per cent alcohol, experiments were performed to determine the effect of weaker concentrations. In the first experiment of this series, young mice two months old, on the basis used above, were divided into three experimental groups and one non-alcoholic control group. One group of experimentals was given 45, another 35, and the third 25 per cent alcohol. Table 2 shows the results of tests completed at different periods after beginning the experiment and lists for each group the average number of cysticercoids counted, the range in number of these, and the calculated percentage development.

The mice that were given 45 per cent alcohol seemed to show a reduced resistance, indicated by percentages of development ranging from 4.1 to 6.0, compared with 1.1 to 3.4 for the controls. Likewise, those given 35 per cent alcohol showed some evidence of a lowered resistance but most of them required a larger number

TABLE. 1.—Comparing the percentage development of *H. nana* var. *fraterna* in alcoholic mice 2.75 months old and in non-alcoholic controls of similar age. Infecting egg dose per animal: 900

Mouse number	Sex	Number of cysticercoids	Percentage development
A. Mice given 20 daily injections of 45 per cent alcohol			
1	M	78	8.7
2	M	62	6.9
3	M	60	6.7
4	M	75	8.3
5	M	80	8.9
6	M	66	7.3
7	F	53	5.9
8	F	60	6.7
B. Non-alcoholic control mice of the same age			
1	M	20	2.2
2	M	12	1.3
3	M	10	1.1
4	M	30	3.3
5	M	15	1.7
6	M	8	0.9
7	F	32	3.6
8	F	12	1.3

of injections. With one exception, it was necessary to give 32–33 injections to obtain percentages of development (5.1–5.2) greatly different from those of controls. On the other hand, even following prolonged treatment, many mice given 25 per cent alcohol did not appear to be affected greatly.

In the second experiment, mice about two months old were divided into three experimental groups, one each on 35, 25, and 10 per cent alcohol, and one non-alcoholic control group. Test infections were given on the day after the experimentals had received 7, 14 and 26 injections respectively (Table 3).

Because of the rather small number of animals in each group, it is difficult to draw definite conclusions in this experiment. In general, however, there is some suggestion of reduced resistance in mice given 14 and in those given 26 injections of 35 per cent alcohol, and in mice given seven injections of 25 per cent alcohol. Those given 10 per cent alcohol did not appear to be affected noticeably, as the percentages of development ranged from 0.4 to 3.0, compared with 1.1 to 2.2 for the controls.

These results tend to show, in general, that 45 per cent alcohol produces a lowered resistance to infection after as few as seven injections while 35 per cent in the same volume requires longer and is less debilitating as shown by parasite numbers. Twenty-five per cent alcohol appears to be on the border line in produc-

TABLE 2.—*Showing the percentage development of cysticeroids in mice given various concentrations of alcohol for different periods as compared with the development in non-alcoholic controls of similar age*

Number of mice	Age in months at infection	Sex	Number of daily alcohol injections	Infecting egg dose per mouse	Nintey-three hour cysticeroids		
					Average number	Range in number	Percentage development
A. Mice given 45 per cent alcohol							
2	2.4	M	7	2000	83.5	71-96	4.2
1	2.7	M	18	1200	49.0	-49	4.1
2	3.2	M	32	1000	59.5	50-69	6.0
B. Mice given 35 per cent alcohol							
2	2.4	M	7	2000	68.5	67-70	3.4
1	2.7	M	18	1200	106.0	-106	8.8
2	3.2	M	32	1000	51.0	40-62	5.1
2	3.2	F	33	1000	51.5	40-63	5.2
C. Mice given 25 per cent alcohol							
2	2.4	M	7	2000	38.5	31-46	1.9
1	2.7	M	18	1200	115.0	-115	9.6
2	3.2	M	32	1000	16.0	14-18	1.6
5	3.2	F	33	1000	38.8	30-47	3.9
D. Non-alcoholic control mice							
3	2.4	M	0	2000	22.6	20-25	1.1
3	2.7	M	0	1200	41.3	34-48	3.4
4	3.2	M	0	1000	22.7	16-30	2.3
5	3.2	F	0	1000	11.2	5-18	1.1

ing debilitation and is less consistent and effective than higher concentrations. Finally, 10 per cent alcohol given in the same volume produces little, if any, visible ill effect on resistance.

3. *The effect on resistance of 25 per cent alcohol given to some mice by mouth and to others by peritoneal route for various periods of time.*—The present experiment was designed to test whether or not alcohol given parenterally produces an effect on resistance similar to that produced by oral injections. Preliminary tests showed that because of rapid absorption following peritoneal injection, alcohol in concentration greater than 25 per cent is not tolerated well by young mice. This concentration, in the volume used above, produced intoxication rapidly but the animals recovered usually within two hours and most of them showed no visible

TABLE 3.—*Showing the percentage development of cysticeroids in mice given various concentrations of alcohol for different periods as compared with the development in non-alcoholic controls of similar age*

Number of mice	Age in months at infection	Number of daily alcohol injections	Egg dose per mouse	Average number of cysticeroids	Percentage development
A. Mice given 35 per cent alcohol					
2	2.3	7	1000	12.5	1.3
2	2.6	14	1000	37.0	3.7
2	2.9	26	1500	49.0	3.3
B. Mice given 25 per cent alcohol					
2	2.3	7	1000	40.5	4.1
2	2.6	14	1000	26.5	2.7
2	2.9	26	1500	40.0	2.7
C. Mice given 10 per cent alcohol					
2	2.3	7	1000	11.5	1.2
3	2.6	14	1000	29.7	3.0
2	2.9	26	1500	5.5	0.4
D. Non-alcoholic control mice					
6	2.3	0	1000	11.8	1.2
7	2.6	0	1000	21.9	2.2
6	2.9	0	1500	16.1	1.1

ill effects after several weeks of daily treatment. Mice about two months old were selected for the experiment and divided into experimentals and controls. One-half of the experimental animals was given 25 per cent alcohol by mouth, the others, after shaving and sterilizing the adomen and using aseptic measures, were given the same dose by peritoneal route. The first infection was given to a few animals of each group and controls ten days after beginning the experiment, and another test was made on the twenty-fifth day. This experiment was repeated with a second series of mice at which time the tests of resistance to infection were made eight and 35 days after the start of the experiment (Table 4).

In the first experiment, the animals given alcohol by mouth and those given the drug by peritoneum had about the same percentages of development (0.9 to 2.6 and 0.9 to 2.2, respectively). These percentages were very similar to those shown by the controls (0.5 to 2.6). In the second experiment, the percentages were much higher in mice of all three groups. Again those receiving the drug by mouth and by peritoneum showed about the same percentages of development (4.1 to 4.4 and

TABLE 4.—Comparing the percentage development of cysticercoids in different mice given 25 per cent alcohol by mouth and by peritoneal route with that in non-alcoholic controls of similar age

Number of mice	Age in months at infection	Number of daily alcohol injections	Egg dose per mouse	Ninety-three-hour cysticercoids		
				Average number	Range in number	Percentage development
A. Mice given 25 per cent alcohol by mouth						
4	2.2	9	1000	8.5	4-13	0.9
8	2.7	24	1000	25.7	4-60	2.6
8	2.0	7	3000	122.4	74-170	4.1
10	2.8	34	2000	87.7	48-151	4.4
B. Mice given 25 per cent alcohol by peritoneal route						
5	2.2	9	1000	9.1	7-12	0.9
8	2.7	24	1000	21.6	2-42	2.2
8	2.0	7	3000	118.9	89-163	4.0
10	2.8	34	2000	109.9	52-246	5.5
C. Non-alcoholic control mice						
4	2.2	0	1000	4.8	3-7	0.5
8	2.7	0	1000	25.6	18-40	2.6
8	2.0	0	3000	95.9	71-112	3.2
10	2.8	0	2000	43.9	15-67	2.2

4.0 to 5.5, respectively). In this case, however, the percentages were much greater than those of the controls (2.2 to 3.2). These results tend to show that the effect on resistance of 25 per cent alcohol is quite variable, being in many cases absent or hardly discernible and in others rather marked. Also, the effect of the alcohol apparently is not related to a direct action on the gastric and intestinal mucosae, since little difference in numbers of cysticercoids was noted in those receiving the drug by mouth and those given peritoneal injections.

4. *The duration of the effect of alcohol on natural resistance.*—The following experiment was planned to test whether or not lowered resistance to infection produced by alcohol persists after discontinuance of the drug. Young mice seven weeks old were matched and divided into two groups. The experimentals received by mouth the usual dose of 35 per cent alcohol which was given daily for 26 days. At this point the alcohol was discontinued so that all animals received the same number

TABLE 5.—Showing the percentage development of cysticercoids in alcoholic mice at various periods after discontinuing the drug and the development in non-alcoholic controls of similar age

Number of mice	Age in months at infection	Days after last alcohol injection	Egg dose per mouse	Ninety-three-hour cysticercoids		
				Average number	Range in number	Percentage development
A. Mice given 26 daily injections of 35 per cent alcohol						
4	2.7	1	1000	75.0	65-81	7.5
8	2.9	8	2000	59.6	35-78	3.0
4	3.0	13	1000	19.0	10-30	1.9
3	3.9	38	1500	24.0	21-29	1.6
B. Non-alcoholic control mice of the same age						
4	2.7	0	1000	29.5	20-39	3.0
8	2.9	0	2000	69.8	50-87	3.5
4	3.0	0	1000	33.5	28-45	3.4
3	3.9	0	1500	22.0	19-26	1.5

of injections. On the following day some mice of each group were infected and a comparison made in the number of cysticeroids that developed. Later tests of resistance were made by infecting representatives of each group eight, 13, and 38 days after the alcohol injections had been discontinued (Table 5).

After the first test infection the alcoholic mice averaged 7.5 per cent development of cysticeroids as compared with 3.0 per cent for the controls. This shows that the alcohol in some way had lowered the resistance to initial infection just as in similar cases above. However, the results of the second infection given eight days after discontinuing alcohol were markedly different. At this time, the experimentals averaged 3.0 per cent development and the controls 3.5 per cent. The comparisons in percentage development of cysticeroids were about as similar as this in the last two infections given 13 and 38 days after discontinuing the alcohol. It appears, therefore, that alcoholic debilitation resulting in a lowered resistance to initial infection with this parasite is temporary only and its duration is dependent

TABLE 6.—Comparing the percentage development of cysticeroids in controls with that in mice given a single intoxicating dose of alcohol immediately before infection

Number of mice	Age in months at infection	Infecting egg dose per mouse	Ninety-three-hour cysticeroids		
			Average number	Range in number	Percentage development
A. Mice intoxicated prior to infection					
6	2.4	1500	6.7	3-10	0.4
12	2.0	900	6.1	3-12	0.7
B. Non-alcoholic control mice					
6	2.4	1500	55.0	40-69	3.7
12	2.0	900	26.7	11-48	3.0

on continued injections of the drug. At least as early as one week after alcohol is removed, natural resistance approaching normal proportions is restored.

5. *The effect on natural resistance of one intoxicating dose of alcohol given immediately before infection.*—In previous experiments, the alcoholic injections were given daily for at least one week before a test was made to determine the effect on resistance. The following experiment was performed to test the effect of one intoxicating dose given just prior to infection. Young mice about two months old were divided into two groups. Those of the experimental group were given 0.8 cc of 25 per cent alcohol by peritoneal route. After complete narcosis, they and their controls were given a test infection of *Hymenolepis* eggs (Table 6). To check on the lowering of body temperature that is known to occur during intoxication, rectal temperatures were taken every one-half hour for the first two hours after infection and on the following morning.

It will be noted that strikingly fewer cysticeroids developed in mice intoxicated just prior to infection than developed in controls. The average percentage development for the experimentals ranged from 0.4 to 0.7 compared with 3.0 to 3.7 for the controls. It is quite evident that the alcohol in some way interfered with the development of cysticeroids. Within one-half hour in most cases the temperature of the intoxicated animals fell from near 98° to 93° F. The drop was not always

as rapid but reached the level indicated or even lower within an hour and remained low for the next hour. By morning the temperature was about normal in every animal. Thus there was a definite correlation between abnormally low body temperature following infection and the development of comparatively few cysticeroids.

Another experiment was carried out to determine whether or not reduced body temperature *per se* has a demonstrable influence on the number of cysticeroids that develop. Preliminary tests showed that when mice were intoxicated and placed at once in a large 37° C incubator the body temperature returned to a near normal level usually within one-half hour, so this method was used to control body temperature after intoxication. Young mice about two months old were divided into two groups, experimental and control. The experimental animals were intoxicated with 0.8 cc of 25 per cent alcohol given intraperitoneally, and immediately they and the controls were infected. Then all of the animals were placed in the incubator overnight. Three different tests of the same kind were made (Table 7).

TABLE 7.—Showing the percentage development of cysticeroids in controls and in mice intoxicated just prior to infection then placed in a 37° C incubator to maintain normal body temperature

Number of mice	Age in months at infection	Infecting egg dose per mouse	Ninety-three-hour cysticeroids		
			Average number	Range in number	Percentage development
A. Intoxicated mice with near normal body temperature					
5	2.5	1200	17.2	12-23	1.4
5	2.0	900	6.2	3-11	0.7
4	2.0	1000	24.0	17-31	2.4
B. Non-alcoholic control mice					
5	2.5	1200	17.8	9-27	1.5
5	2.0	900	8.2	4-12	0.9
4	2.0	1000	23.5	16-30	2.4

The results of the three tests are very similar. The experimental mice showed percentages of development that ranged from 0.7 to 2.4, whereas those of the controls ranged from 0.9 to 2.4. It was not possible to include a second control group to be kept at room temperature. However, the percentages of development for the controls used compare favorably with those recorded in experiments above from mice of this age given similar numbers of eggs. Although other factors cannot be excluded, the obvious conclusion is that one intoxicating dose of alcohol given prior to infection has no effect on the number of cysticeroids that develop provided near normal body temperature is maintained. It would appear, therefore, that reduced body temperature *per se* interferes with the development of the parasite.

DISCUSSION

Mice given 45 per cent alcohol daily showed a lowered resistance to *H. nana* var. *fraterna* within one week, but the most pronounced effects were seen after 20 daily injections (Tables 1 and 2). The animals on 35 per cent alcohol likewise showed reduced resistance, but in this case it usually required at least two weeks treatment (Tables 2, 3, and 5). The effect on resistance of 25 per cent alcohol was extremely variable as shown in Tables 2, 3 and 4. Even following prolonged treatment many animals appeared unaffected, while others showed some evidence of reduced resist-

ance after seven injections (Table 4). Finally, the few animals given 10 per cent alcohol for various periods of time exhibited no noticeable ill effects on resistance (Table 3). It appears, therefore, that alcohol in a concentration of 45 per cent even following a small number of doses is definitely detrimental to the natural resistance of young mice. As the concentration of the drug is decreased, it usually requires a larger number of doses to produce ill effects on this resistance. When the concentration is decreased to 10 per cent no demonstrable changes are evident. These results seem to confirm the commonly expressed view that the effect of alcohol on resistance to infection depends in large measure on the concentration consumed and the time interval of consumption.

Two observations of the above series deserve comment. One is the great differences in the susceptibility to alcohol. Individual animals show all grades of tolerance to the drug as reflected in the rapidity and duration of intoxication and its effect on physical appearance and behavior. Others have pointed out this variation in susceptibility of rabbits (Rubin, 1904; Friedenwald, 1905). Although direct tests were not carried out, there was some suggestion of a correlation between tolerance to the drug and the degree of debilitation produced. The other observation was the percentage development of cysticercoids in the control mice. It will be noted from the various tables that the percentages are considerably lower than in previous studies in which the eggs for infections were stored before isolation (Larsh, 1943b). The use of unstored eggs in the present study probably accounts for the lower rates, since these percentages compare fairly well with those obtained elsewhere under similar experimental conditions (Larsh, *ibid.*).

As mentioned above, certain factors have been shown to have an influence on the natural resistance of mice to infection with *H. nana* var. *fraterna*. Age alone seems to be influential as mice less than one month or over four months are strikingly more resistant to infection than those about two and one-half months old (Shorb, 1933; Hunninen, 1935; Larsh, 1943a). Increased resistance to initial infection is also shown by mice infected simultaneously with *Nippostrongylus* (Larsh and Donaldson, 1944). On the other hand, under certain experimental conditions mice may exhibit decreased resistance to infection. This is shown by old mice splenectomized when young. These were much more susceptible to an initial infection than mice of the same age with intact spleens (Larsh, 1944). Also, as demonstrated above, alcohol in high concentrations produces a high grade debility shown by increased susceptibility to infection. Just how these stimulating or debilitating effects are produced is as yet unknown, but the mechanism should be studied further because of its importance in explaining the function of natural resistance.

SUMMARY

The effect of alcohol on the natural resistance to *H. nana* var. *fraterna* has been studied in a large number of white mice. In general, 45 per cent alcohol by mouth produced definite debilitation after 20 daily injections and some impairment of resistance within one week, whereas 35 per cent, although producing debilitation in many cases, required a longer period of time. A concentration of 25 per cent alcohol produced extremely variable effects on resistance while 10 per cent did not appear to produce change. These results seem to confirm the commonly expressed

opinion that the effect of alcohol on resistance depends largely on its concentration. The effect of the drug differed very little when given by mouth and by peritoneum which showed that possible gastric and intestinal damage following oral administration has little, if any, influence on the number of parasites that develop. Lowered natural resistance produced by the drug was temporary and disappeared in all cases within one week after discontinuing treatment. Finally, one intoxicating dose of alcohol prevented the development of usual numbers of cysticercoïds from a test infection given soon after narcosis. If normal body temperature was maintained by artificial means, however, similar numbers developed in the intoxicated mice and their non-alcoholic controls. This is interpreted to mean that abnormally low body temperature, evident during intoxication, interferes with the development of the parasite.

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THE MORPHOLOGY OF *TAMERLANIA BRAGAI* DOS SANTOS, 1934

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Tamerlania bragai was described by Dos Santos (1934) as *Tamerlanea bragai* (obvious misspelling of *Tamerlania*) from the kidneys and excretory ducts of domestic pigeons and chickens at Rio de Janeiro. It was reported from the pigeon in São Paulo by Reis and Nobrega (1936), in the Philippines by Tubanguí and Masiluñgen (1941), in Puerto Rico by Maldonado and Hoffman (1941) and from turkeys in Brazil by Barretto and Filho (1942). All of the Latin American authors spelled the generic name "*Tamerlanea*" and none of the accounts reported the presence of an acetabulum.

The genus *Tamerlania* was erected by Skrjabin (1924) to contain *T. zarudnyi* from *Passer montanus* in Russian Turkestan. Khitrowo-Kalantarian (1925), from original observations and from information communicated by Skrjabin and by Issaitschikow, reported the parasite from four additional species of birds and stated that the digestive ceca unite posteriorly. Other described species include *T. meruli* by Nezlobinski (1926), *T. bragai* by Dos Santos (1934), *T. japonica* by Yamaguti (1935) and *T. melospizae* by Penner (1939). Yamaguti (1941) reported that *T. japonica* is specifically identical with *T. zarudnyi*. Penner formulated a key to the species of the genus, the original diagnosis of which was emended or amplified by each of the subsequent writers. Whether an acetabulum is present in species other than *T. bragai* remains to be determined.

Skrjabin (1924) also erected the family EUCOTYLIDAE to contain *Eucotyle* Cohn, 1904 and two new genera, *Tanaisia* and *Tamerlania*. Two additional genera, *Lepidopteria* and *Ohridia* were added by Nezlobinski (1926). The family characters were stated by Fuhrmann (1928) and reviewed by Cheatum (1938) and Penner (1939). According to these authors the worms are monostomes, parasites of the renal ducts of birds. The family is world-wide in distribution, the hosts are chiefly migrants, and several of the species have been described on the basis of limited material. As a result, the morphology is imperfectly known and the validity of certain genera and species is questionable.

In a personal communication, dated September 25, 1942, Dr. William A. Hoffman wrote that one of his students, Mr. José F. Maldonado, had found that *T. bragai* possesses a small ventral sucker. Dr. Hoffman stated that after publication of the note, Maldonado and Hoffman (1941), Mr. Maldonado had discontinued his studies on *T. bragai*, but that the presence of an acetabulum in the species should be of interest in determining the phylogeny of the monostomes and offered, with the reservation that the discovery of the acetabulum should be accredited to Maldonado, to place the material at my disposal. The material sent by Dr. Hoffman consisted of one mounted specimen (Fig. 1) and an incomplete set of serial sections of the kidney. The study was completed and a manuscript prepared, giving credit to Mr. Maldonado for discovery of the acetabulum. Subsequently, Mr. Maldonado returned to Puerto Rico and continued his studies on *T. bragai*. Fol-

lowing correspondence and a conference with me, Maldonado (1943) published a preliminary note announcing the discovery of the acetabulum and of the life cycle, and suggested the publication of two separate papers, preferably simultaneously and in the same journal, his to deal with the life history, epidemiology and pathology of *T. bragai* and mine to consider the morphology and taxonomy of the parasite. Accordingly, my account was withheld and his, received for publication May 8, 1945, appears in this issue of the Journal of Parasitology.

The specimens from Puerto Rico do not agree completely with the original description of *T. bragai*, and to check their specific identity, Professor Travassos sent additional material from the Instituto Oswaldo Cruz. Grateful acknowledgment is made her for his kindness and cooperation. The specimens from Rio de Janeiro, sent by Travassos, are morphologically and presumably specifically identical with those from Puerto Rico. Although they do not agree in all particulars with the description of *T. bragai* given by Dos Santos (1934), there are strong reasons for believing that they belong to the same species. Differences between these specimens and Dos Santos' account are noted in the following description.

Tamerlania bragai Dos Santos, 1934

The body is flattened dorsoventrally, with almost parallel sides and rounded ends. Both small, sexually immature, and large, gravid worms may be present together in long-established infections. This observation and the presence of hundreds of specimens in a single kidney, indicate repeated infection with the development of little or no immunity. A specimen 0.6 mm long is immature; gravid worms measure 1.2–3 mm long, 0.2–0.45 mm wide. In cross sections the body is oval; the thickness varies inversely as the width. In large tubules the worm is usually flatter; in small tubules it may be almost round in section. An acetabulum (Figs. 1, 4) is regularly present, 0.04–0.05 mm in diameter, situated in the anterior part of the middle third of the body. The thickness of its wall is about equal to the diameter of the lumen and the organ is probably functionless. The body wall of the worm consists of circular, longitudinal and oblique muscle sheets, but all are weak and poorly developed. The parenchyma is loosely organized and, in fully mature specimens, most of the body is occupied by the gravid coils of the uterus. The cuticula bears flat, chisel-like, recurved spines (Figs. 2, 3). The base is a flattened oval, thicker and often slightly wider than the blade which tapers to a thin edge. The largest ones measure about 0.008 mm wide at the base and about 0.01 mm long. Frequently the blade may be resolved into several (3–8) fused elements with as many distinct points at the free edge.

The mouth is subterminal; the oral sucker is well developed, 0.1–0.145 mm in diameter. (Dos Santos gave the size as 0.5 mm wide and 0.41 mm long, but his figure shows the sucker about one-half the body width which he stated was maximally 0.66 mm.) The oral sucker communicates directly with the pharynx, which usually indents the posterior wall of the oral sucker, and which measures 0.045–0.065 mm in diameter. (Dos Santos measurement is 0.16 mm.) The pharynx is followed by a short esophagus, recognizable only when the anterior end of the worm is extended. In sections, the epithelium of the digestive ceca extends to the pharynx. The ceca, of variable diameter, unite near the posterior end of the body (Fig. 1), thus forming a loop, the ends of which are almost equidistant from the corresponding ends of the body. The ceca contain a granular coagulum; no nuclei of ingested cells were observed, but Fig. 5 suggests that the worms may attack the renal epithelium.

The excretory pore is terminal and the vesicle could be traced forward, ventral to the uterine coils, as far as the level of the intestine.

The testes are opposite or slightly diagonal in position and frequently overlap each other in the median plane. They are situated a short distance behind the ovary, in the posterior part of the anterior half of the body, and at the level of the acetabulum. When small, they are dorsal in position. They are oval, longer than wide, slightly lobed, and difficult to measure. In mature specimens they are 0.12 by 0.09 mm to 0.22 by 0.18 mm. (According to Dos Santos the testes are 0.5 mm long and 0.35–0.47 mm wide, but in his figure they are represented as smaller than the ovary for which he gave the measurement 0.15 mm long by 0.22 mm wide.) Vasa efferentia arise at the anteromedian faces of the testes, pass forward and mediad, dorsal to the ovary. They enter separately into the large, posterior end of a pyriform seminal vesicle,

which is closely invested by a muscular wall and may be regarded as a cirrus sac. The vesicle is median, lies in part dorsal and in part anterior to the ovary, and measures 0.06–0.07 mm in diameter. Ventrally the vesicle is continuous with a short, muscular canal which leads to the shallow genital sinus. There is a space, occupied by loose mesenchymatous tissue, between the canal and the muscular wall of the sac. Dos Santos described the structure as “un tout petit cirre atrophé.” The genital pore is median, ventral, below the anterior end of the ovary.

The ovary is lobed, slightly wider than long, and measures 0.1–0.2 mm in diameter. (According to Dos Santos the ovary is 0.15 mm long and 0.22 mm wide.) It is situated about one-third of the body length from the anterior end; it occupies the region between the ceca but is slightly displaced toward one side, left or right, by the uterus which passes forward on the opposite side. The oviduct arises at the dorsal surface, bends dorsad, mediad and backward where it receives a very short duct from a small seminal receptacle. No Laurer's canal was observed, but fixation of the tissue was not good enough to preserve delicate structures perfectly. The oviduct then receives a short duct from the vitelline receptacle and passes ventrad through Mehlis' gland to form the initial part of the uterus. The uterus passes backward, dorsal to or between the testes (Fig. 4) and turns toward the ovarian side; it continues in loops and coils almost to the posterior end of the body where it turns forward and returns in the same manner, passes between and below the testes (Fig. 4), makes a transverse loop between the testes and the ovary, and passes forward on the antovarian side of the body above the digestive cecum but median to the vitelline follicles at that level. It continues in irregular coils to the region of the pharynx and back to the level of the ovary where a short, thick-walled metraterm leads to the genital sinus. The vitellaria consist of well-developed follicles which form almost continuous columns in the extracecal areas. They extend forward about one-half the distance from the genital pore to the anterior end of the body and backward about one-half of the distance from the ovary to the posterior end of the body. (Dos Santos stated, “Les vitellogènes sont placés exclusivement aux champs latéraux, pré et retotesticulaires, depuis 0.32 mm de l'extrémité antérieure de la ventouse orale jusqu'à 0.32 mm de l'extrémité postérieure du trematode.” In his figure, however, the vitellaria have the same distribution as shown in Fig. 1, and are at least twice as far from the posterior as from the anterior end of the body.) Vitelline ducts pass mediad dorsal to the ceca, at the level of the ootype and unite to form the vitelline receptacle. Eggs in the initial portion of the uterus have thin, transparent shells and contain ova; those in the terminal portion have thick, yellow shells and contain fully formed miracidia. The eggs are operculate, often slightly flattened on one side, and measure 0.034 by 0.015 mm. (According to Dos Santos, the eggs measure 0.031 by 0.013 mm; although I have measured eggs of this size, in the present material the average is slightly larger.)

Tamerlania bragai is the only member of the EUCOTYLIDAE whose life history is known and the only one in which an acetabulum has been reported. According to Maldonado, the sucker appears early in the development of the cercaria and fails to continue its growth, thus suggesting that here it is a vestigial rather than a rudimentary structure. The discovery of an acetabulum in this species affords new and significant information touching on the status of the suborder, MONOSTOMATA. The phylogeny of the monostomes was discussed by Stunkard (1934) and a further consideration of the subject is to appear in a forthcoming number of Biological Reviews of the Cambridge Philosophical Society.

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EXPLANATION OF FIGURES

ac—acetabulum	ph—pharynx
ev—excretory vesicle	sv—seminal vesicle
in—intestine	ts—testis
os—oral sucker	vt—vitellaria
ov—ovary	

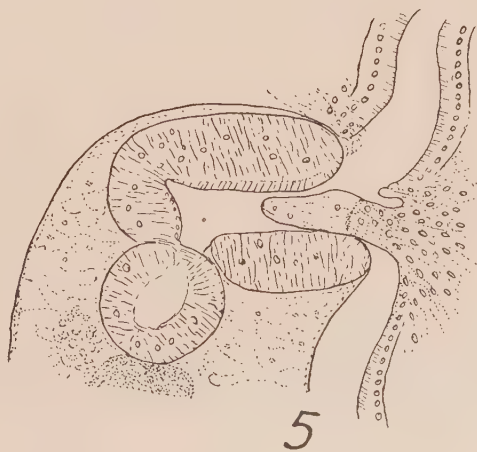
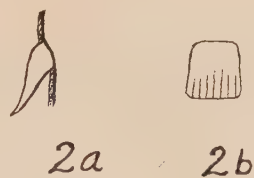
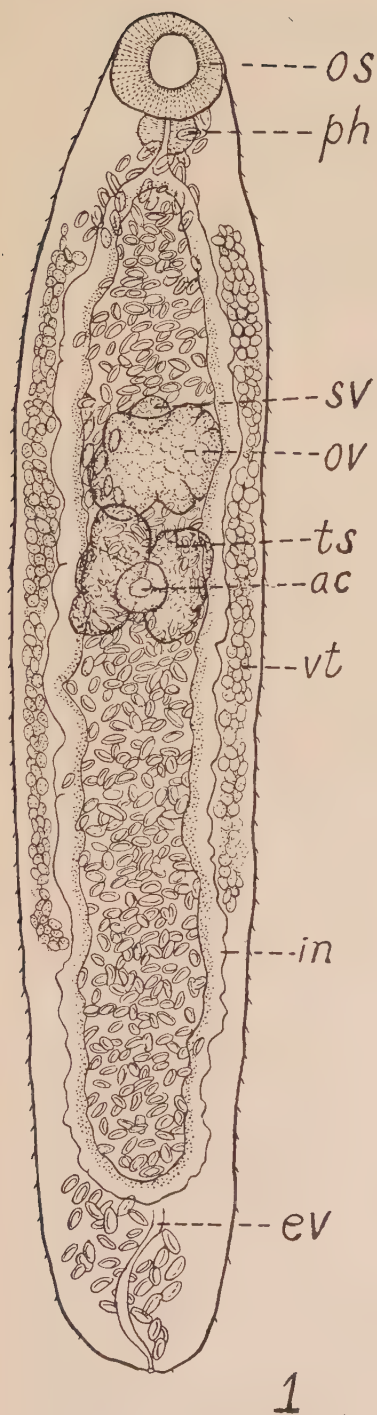
FIG. 1. Whole mount, ventral view, specimen from Puerto Rico. It measures 1.31 mm long, 0.252 mm wide and probably is not completely mature.

FIG. 2. Normal spines; 2a side view, 2b front view.

FIG. 3. Variations observed in spines.

FIG. 4. Cross section of mature specimen at the level of the acetabulum, showing testes, vitellaria, intestinal ceca, the descending limb of the uterus with thin-shelled eggs on the dorsal and the ascending limb with thick-shelled eggs on the ventral side of the body. Specimen from Rio de Janeiro, 0.3 mm wide.

FIG. 5. Sagittal section of the anterior end of a worm, situated where a small tubule opens into a large one, showing a portion of the excretory tubule drawn into the oral sucker; the epithelium is absent and the underlying tissues distorted.



THE LIFE CYCLE OF *TAMERLANIA BRAGAI*, SANTOS 1934, (EUCOTYLIDAE), A KIDNEY FLUKE OF DOMESTIC PIGEONS

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In the course of study of several Puerto Rican trematodes the author obtained a larval form from specimens of the terrestrial snail *Subulina octona*, collected in the neighborhood of a pigeon house. In a preliminary study, Maldonado (1943) identified this form as *Tamerlania bragai*, a trematode inhabiting the urinary passages of domestic pigeons in Brazil and Puerto Rico. The present report describes in detail the life cycle of this parasite.

MATERIALS AND METHODS

The intramolluscan phase of the cycle was studied by experimental infection of laboratory-raised *Subulina octona*. Previous trials had demonstrated that eggs of *Tamerlania* fail to hatch in the open. The snails were therefore exposed by allowing them to feed on sedimented droppings of parasitized pigeons. Every four days after the period of exposure, two snails were removed from their shells and fixed in Zenker's solution. They were sectioned serially and stained in Bullard's hematoxylin-eosin, although the more advanced stages of development were studied *in vivo* preferably. The miracidium was studied by removing the gut of snails within one-half hour after they were observed ingesting the excreta and examining directly under the microscope or in sections.

The process of infection and development of the fluke in the pigeon was determined by feeding infected snails to young birds and killing subsequently at various intervals beginning six hours after infection. The parasites were fixed in corrosive sublimate-acetic acid and stained in Ehrlich's acid hematoxylin or in Alum cochineal-Delafield hematoxylin.

EXPERIMENTAL RESULTS AND OBSERVATIONS

The egg (Fig. 1).—The egg of *Tamerlania bragai* has a thick, brown, smooth shell which is elongated and slightly asymmetrical. It is provided with an operculum anteriorly and with a small protuberance posteriorly. The egg measures on the average 30 microns in length by 15 microns in width. The miracidium is fully developed and infective at oviposition. It fills practically all the egg cavity except for a narrow space at the anterior end occupied by refractile granules. All unhatched miracidia present a triangular, fibrillous mass slightly anterior to the middle of the body.

Eggs are usually observed in great numbers in the fluid part of the droppings. In heavy infections the irritative action of the parasite causes an increase in excretion so that urine practically free from feces is often passed. In these cases, eggs are obtained in almost pure concentrations. The examination of solid excrement, however, constitutes a reliable means of diagnosis due to the admixture of feces with urine in the cloaca. Under favorable conditions of humidity and aeration the

egg may remain infective for a considerable time. In well-aerated charcoal cultures or in clean rain water it lives for over a month.

The miracidium (Fig. 2).—Hatching takes place in the distal end of the stomach of the mollusc. The process is identical with that observed in other trematodes. Within fifteen minutes after the egg arrives in the crop the operculum is suddenly released and the embryo is extruded within its embryophore. Tearing out from this envelop is relatively easy and the miracidium is then free to move in the lumen of the snail gut.

The minute size and cryptic habits of the miracidium did not permit its study in detail. No miracidia could be freed from the egg by artificial means. It was thus necessary to study them through the gut wall, a circumstance which contributed to obscure the details. Fig. 2 is therefore a diagrammatic representation of the miracidium as observed within the intestine of the snail. The larva is about 30 microns long, pyriform, with a small anterior snout-like projection. Ciliation is uniform, giving the organism a smooth motion which is accompanied by peristaltic contractions. The triangular, fibrillous mass of the unhatched form could not be observed. The parenchyma possesses scattered refractile granules. In sections, a pair of delicate nuclei representing the germ cells, were observed.

The mother sporocyst.—The miracidium may reach the tissues of the snail by piercing the intestinal epithelium. This route of migration is suggested by the presence of early developmental stages in the peri-intestinal connective tissue, in the kidney and in adjacent parts of the digestive gland.

Within four days after ingestion of the egg, the miracidium has transformed into a mother sporocyst which appears as a round, solid mass of cells with deeply staining nuclei. On the eighth day it has grown diffusely among the tissues and only loosely scattered groups of germ cells lacking definite organization can be observed. On rare occasions a thin membrane may be seen enclosing these cells. The parasite has apparently relinquished, to an extreme degree, its somatic capabilities for the germinative ones. Beyond the eighth day the increase in number and size of the germ balls obscures the outlines of the mother sporocyst. The production of new germ balls continues for a considerable time. However, the germinative capacity depends to a great extent on space relations within the host. The duration of the mother sporocyst has been established as two months. Beyond this time the size of the brood mass prevents further proliferation and all the daughter sporocysts eventually reach the same stage of development.

The daughter sporocyst (Figs. 3 and 4).—The development of the second generation of sporocysts resembles closely that of most trematodes. The germ cells in the mother form may divide and separate repeatedly, but when some fail to do so a germ mass arises. In *Tamerlania bragai* this process takes place as early as the fourth day of life in the snail, at the time when the mother sporocyst is still a solid structure. At this stage a number of cells with different staining properties may be observed forming a compact group at the center.

The germ balls grow by cell multiplication. Eight to ten days after arising, they break out of the mother sporocyst. The majority remain about the middle of the snail body, forming a compact mass which distorts the digestive gland considerably. Others may move to more distant parts.

Around the twelfth day, differentiation of the germ mass into the ultimate form begins. A body cavity develops and a cercarial germ mass may segregate simultaneously from the body wall. At maturity the daughter sporocyst becomes a passive, simple, spherical or ovoid, saccular structure enclosing a few cercariae at various stages of development. The body wall is very thin and undifferentiated. The size varies with the number of cercariae. Those in which a single cercaria has arisen measure about 200 microns in diameter, others with eight or ten cercariae vary between 500 and 600 microns in diameter.

The cercaria (Fig. 5).—The cercariae of *Tamerlania bragai* arise, as in other trematodes, by the proliferation of the germ cells within the daughter sporocyst. Although a sporocyst may give rise, simultaneously with the formation of the body cavity, to only one individual, the majority of the sporocysts produce several cercariae at different intervals during development. The latter may be seen to arise from germ cells lying along the body wall of the sporocyst. These form small masses which project for a time into the cavity and later detach. Following a period of growth by cell multiplication the germ ball elongates.

The suckers are the first organs to appear. An acetabulum arises as a knob near the midbody. The oral sucker develops by a constriction of the most anterior part of the body. The buccal cavity first appears as an anterior depression in the oral sucker. Because of greater growth of the dorsum this sucker and its cavity will come to lie subventrally as development proceeds. The pharynx in its earliest stage is prominent, about half as large as the oral sucker. An excretory vesicle arises by fusion of the distal parts of two lateral collecting tubules in the elongating germ mass. The secretory system is formed simultaneously with the other organs. Cystogenous glands arise from cells scattered throughout the body, since numerous aggregations of greenish secretory granules may be observed in early stages. There is no evidence of the formation of ducts.

The first fully developed cercariae appear on the fourth week of infection. The organism is markedly delicate. It is entirely unable to survive outside of the host or even to leave the shelter of the sporocyst. Its activities are restricted to slow movements of the body, particularly of the fore part which is most often curved ventrad (Fig. 5) thus causing the parasite to lie on its side. The body is cylindrical, tapering slightly posteriorly and covered with a thin, rugose cuticle. The pre-acetabular region is thicker because of the greater size of those cystogenous glands which lie in it.

The oral sucker, which lies subventrally, is an elongated, muscular structure. The oral cavity is funnel-like and divides the sucker into a small, lower lip and a large, upper one. The acetabulum is globular and stands out prominently, the sucker cavity varying in size and shape with the state of contraction. The claviform excretory bladder is the only observable portion of the excretory system. The flame cells and ducts are obscured by the cystogenous glands. A rudimentary tail is represented by a small stub in some cercariae. In others the posterior tip of the body is twisted, giving a false impression of a tail rudiment.

Average body measurements of living cercariae are: Length of body, 400 microns; width at middle, 50 microns; oral sucker—length, 45 microns; acetabulum—diameter, 25 microns; pharynx—diameter, 18 microns; oral sucker to acetabulum, 150 microns; acetabulum to tip of body, 210 microns.

The metacercaria (Figs. 6 and 7). As early as the thirtieth day of infection those cercariae which have attained maturity proceed to encyst within the sporocyst. The actual process of encystation was not observed. It is supposed that the glandular secretions are extruded through the integument since no ducts could be outlined. The cyst formed is leathery, elastic and transparent, between 4.0 and 7.5 microns in thickness. The entire structure is oval, measuring about 146 microns by 36 microns. In old infections the encysted cercariae may be found in masses still surrounded by remnants of the disintegrating sporocyst, although in many cases the latter have entirely disappeared.

Encystment marks a turning point in the organization and behavior of the parasite. From then on it may be seen to move vigorously and almost constantly within its enclosure. During this stage the larva becomes prepared to endure the arduous journey to its final habitat in the definitive host.

When freed from the cyst by the normal process of digestion in the pigeon, the metacercaria appears as a flat, leaf-like and delicate organism, measuring about 360 microns in length. This shape is evidently attained upon the discharge of the cystogenous secretions. The body covering has become thick and striated, with short, blunt papillae which are more numerous on the anterior margin of the oral sucker.

The oral sucker is subventrad, perfectly round when seen *en face* and about 36 microns in diameter. The oral cavity is large and leads into a muscular pharynx about 18 microns in diameter. A very short esophagus opens from the pharynx and bifurcates into the thin, undulating crura which unite posteriorly. The acetabulum is globular and muscular, almost as large as the oral sucker, and protrudes markedly from the ventral surface. When expanded, the acetabular cavity is shallow and hemispherical.

The excretory system is clearly visible. The bladder is thin, undulating, and opens ventrad. It extends to the level of the acetabulum where it bifurcates at right angles into two main trunks each of which in turn subdivides into an anterior and a posterior secondary duct. The former is convoluted and extends forward turning back on itself at the level of the oral sucker to end in the vicinity of the acetabulum. The latter is undulated and ends at the posterior end of the body. The flame cells are forty in number, arranged in pairs on the sides of the body. Their relative position varies but in general eight pairs are located preacetabulad and the other twelve postacetabulad.

A small compact mass of cells in front of the acetabulum constitutes the genital primordium. Two sets of small glands, about ten in total, lie behind the bifurcation of the esophagus. The ducts from each set project forward over the dorsal surface of the oral sucker, forming a complex. There is no evidence of an external opening. These glands probably correspond to the cephalic glands of other trematodes and may already be present in the cercaria although obscured by the cystogenous glands.

Development in the Final Host

Mode of infection of the pigeon.—Pigeons acquire the infection only upon the ingestion of the infective snail. Birds are markedly fond of snails which they supposedly use as grit. In the case of *Subulina octona*, the mollusc under consideration, the shiny, cream-colored shell acts as an added attraction. The facility with

which the parasite is acquired in nature is expressed in the high incidence of infection, as much as 90 per cent in many localities. Parent birds may even infect their brood by feeding them infective material.

Ingested snails are crushed in the gizzard and the liberated metacercariae pass into the duodenum where they readily excyst. Five to six hours after feeding infective snails the actively moving metacercariae may be obtained from the entire length of the digestive tract, in the cloaca and along the ureters. Some may even have reached the kidneys by the latter route. In every instance this has been the only proved mode of arrival in the kidneys.

Development of the adult.—On the fourth day of life in its final habitat (Fig. 8) the parasite measures about 600 microns in length, that is, over twice its original size. The shape of the body and arrangement of the organs are practically the same as in the metacercaria. The most marked structural alterations are the enlargement of the genital primordium and the segregation of the ovary from its anterior portion as a round cell mass.

On the eighth day (Fig. 9) the remaining portion of the genital anlage has differentiated into a pair of testes which lie close together immediately behind the ovary, two small masses representing the primordia of the vitellaria, located directly over the gut on each side of the acetabulum, and a strand of cells extending back dorsad to the acetabulum representing the beginnings of the uterus. At this stage the parasite has attained a length of about 950 microns. The body covering is considerably changed due to the deepening striations which have begun to acquire the shape of spines. The oral sucker, the pharynx and the intestine have increased correspondingly in size. The acetabulum, although showing slight enlargement, has failed to grow at the same rate.

Between the eleventh and the fifteenth day (Fig. 10) the fluke attains adulthood. The first eggs lie already in the distal end of the uterus near the genital opening, but the majority appear only as distorted, empty shells. The vitellaria, testes and ovary are fully developed and functional. The relative position of the testes has changed. The post-acetabular body region has markedly elongated to make room for the enlarging uterus. A small yolk sac is located just in front of the testes. The seminal vesicle is large, extending over the dorsal surface of the ovary. At this stage the worm is about 1.25 mm long. The body covering is definitely spiny. The acetabulum is atrophic, measuring less than 40 microns in diameter, or even absent in some specimens.

From now on the morphological changes consist of enlargement of the whole body and gradual accumulation of eggs until they obscure practically all the organs. Oviposition starts during the fourth week of infection.

DISCUSSION

The present observations on the life history of *Tamerlania bragai* are of interest not only because they constitute the first record on the life history of members of the family EUCOTYLIDAE, but also because they shed some light on the phylogeneses of this group of parasites and thus help to clarify their true systematic position.

The family EUCOTYLIDAE was created by Skrjabin (1924) for digenetic monostomes of the urinary organs of birds. It includes five genera: *Eucotyle* Cohn 1904, *Tanaisia* Skrjabin 1924, *Tamerlania* Skrjabin 1924, *Ohridia* Nezlobinski

1926 and *Lepidopteria* Nezlobinski 1926. The genus *Tamerlania* was originally created for eucotylids without the anterior muscular prominence typical of *Eucotyle*, with vitellaria extending from the testes backwards, with testes located close together, side by side and with esophagus lacking. It was later modified by several authors (Penner, 1939) to include the presence of a short esophagus, the union of the intestinal crura at the posterior end in some species and the extension of the vitellaria in front and back of the testes. On this basis the genus includes four species: *T. zarudnyi* Skrjabin 1924, *T. meruli* Nezlobinski 1926, *T. bragai* Santos 1934 and *T. melospizae* Penner 1939. A fifth form, *T. japonica* Yamaguti 1935, was considered at a later date synonymous with *T. zarudnyi* by its creator (Yamaguti, 1941).

The taxonomy of these trematodes, both in the genus *Tamerlania* and in the family EUCOTYLIDAE, has been based entirely on adult characters, host relations and geographical distribution. Since nothing was known of the particular life cycles, the larval characters could not be used in their classification. As far as *Tamerlania bragai* is concerned, the presence of an acetabulum during larval development as demonstrated in this work makes its present taxonomic position in the suborder MONOSTOMATA untenable. This example is a further addition to the already long list of cases in the literature which show that the classification of trematodes should not be based exclusively on the characteristics, morphological or otherwise, of the adult form. The significance of these observations in respect to the other members of the family will be determined only upon the elucidation of their respective life cycles.

The acetabulum of *Tamerlania bragai* was first observed by the author five years ago in a young adult specimen obtained from a naturally infected pigeon. The organ was subsequently demonstrated in other specimens upon sectioning. This material was forwarded to Dr. Horace W. Stunkard of New York University for a detailed study. The result of his observations will appear in a separate article.

SUMMARY AND CONCLUSIONS

The life history of *Tamerlania bragai*, a fluke of the urinary passages of pigeons, described originally by Santos (1934) from Brazil and later reported from Puerto Rico by the present author, is described. This is the first record on the life history of members of the family EUCOTYLIDAE.

Subulina octona, a land snail, acts as intermediate host. The egg is ingested by the snail and hatches in the crop. The miracidium invades the connective tissue and develops there into a very delicate mother sporocyst. This gives rise to numerous daughter sporocysts, each of which in turn gives rise to a few cercariae. The cercaria is a highly specialized organism which spends its entire life in the sporocyst and eventually encysts within it. The larval cycle is completed in a month. Pigeons acquire the infection upon the ingestion of snails bearing encysted cercariae. After excystation in the duodenum the metacercariae move down into the cloaca from where they pass into the ureters and thence finally to the kidneys. Some parasites may reach these organs as early as five hours after the snail is ingested by the pigeon. The fluke becomes sexually mature at the end of the second week. Eggs may be recovered in the urine and excreta of the pigeon on the twenty-third day.

The presence of an acetabulum in this parasite demands a revision of its taxonomy. This organ occurs in all the cercariae and young adults. In the latter it may grow slightly, but eventually atrophies and as a rule cannot be observed at sexual maturity. A reconsideration of the taxonomy of the other members in the group must await further knowledge of their biology.

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EXPLANATION OF PLATES

- FIG. 1. The egg.
 FIG. 2. Miracidium obtained from the crop of the snail. Diagrammatic.
 FIG. 3. Daughter sporocyst. Segregation of the first cercarial germ ball and formation of a body cavity. From sections.
 FIG. 4. Daughter sporocyst—diagrammatic. Demonstrates cercarial germ balls and encysted cercariae.
 FIG. 5. The mature cercaria.
 FIG. 6. The encysted cercaria.
 FIG. 7. Excysted metacercaria lying slightly on its right side. Flame cells of the left side shown only.
 FIG. 8. The parasite on the fourth day of life in the kidneys.
 FIG. 9. Eight-day-old stage.
 FIG. 10. Young adult at 2 weeks of age.



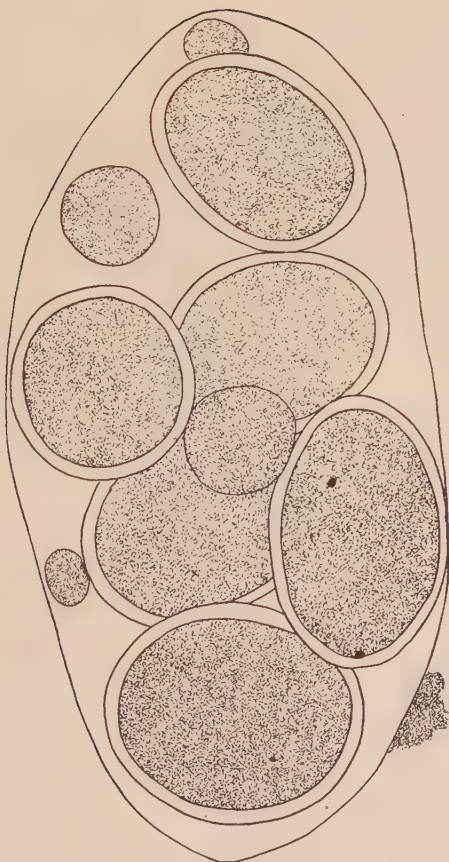
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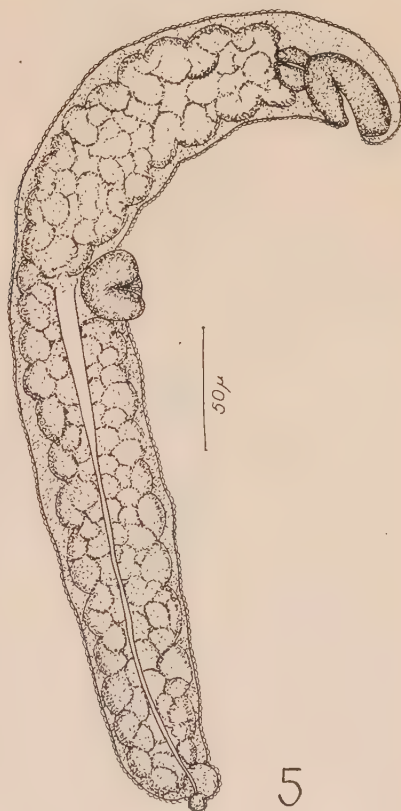
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ANOPHELES NATALIAE, A NEW SPECIES FROM GUADALCANAL

JOHN N. BELKIN, Captain SnC, AUS

During a search for breeding places of *Anopheles solomonis* Belkin, Knight and Rozeboom (1945) in the coral foothills of northwestern Guadalcanal a third species in the *lungae* series was discovered and is described in this paper.

Anopheles (Myzomyia) nataliae, n. sp.

ADULT FEMALE.—A medium-sized, grayish-brown, speckled anopheline; apical sixth to fifth of labium with a ring of light yellow scales. Length of wing, 3.5–4 mm.

Head (Fig. 1): Ornamentation of head and antennae as in *solomonis*. Palpi usually reaching to labella, ornamented as shown in Fig. 1; second and third morphological segments black with narrow ring of white scales at apex, frequently a patch of bronzy scales dorsally in center; fourth and fifth segments each black-scaled basally for a fourth to a third of its length, remainder white, often tinged with yellow; ratio of fourth segment to third segment 1: 1.6–1.7. Labium dark-scaled basally, apical sixth to fifth with a ring of light yellow scales, conspicuously separated from the basal black ventrally, gradually merging into it dorsally; a preapical band of dark scales, often interrupted dorsally.

Labella dull yellow. Buccopharyngeal armature (Fig. 2) of several broad central teeth forming a single row; teeth of similar character, separated by intervals; apices of teeth with many spicules, one of which is elongated, bases with bullae and lateral spines.

Thorax: Scutal integument grayish-brown with gray pollinose areas; dark brown eye spots in front of and behind scutal angle; prescutellar space, disc of scutellum and a small area in front of wing root dark brown. White scales on anterior promontory rather short and sparse; central scales elongate anteriorly, posteriorly short and extending one-fourth length of scutum; lateral scales broader, a patch of black scales on humeral angles below lateral tufts. Fossae with several small, broad, recumbent, translucent light scales; long, narrow, whitish scales mixed with whitish hairs in front of wing root. Remainder of scutum and all of scutellum without conspicuous broad scales, vestiture consisting of numerous golden hairs of varying length, some of these appear scale-like under high magnification. Scutal and scutellar bristles light brown. Prothoracic lobes with a large patch of short black scales on upper part. Pleura without scales, integument gray-brown with usual darker lines and spots. Spiracular bristles absent; propleurals 3–5 stout and 2–4 shorter, more slender dark bristles; lower sternopleurals several golden hairs; upper sternopleurals 2–3 dark bristles and variable number of light hairs; prealars 5–10 golden hairs; subalars 5–10 golden hairs; lower mesepimerals absent. Halteres light with dense white scaling on upper part of shaft and all of knob. *Wing* in general as described and figured for *solomonis*; extremely variable; dark sectoral spot (between basal and median dark costal spots) usually reduced, absent, or fused with median dark spot; dark fringe spots frequently more extensive than in *solomonis*. *Legs* speckled, in general as described for *solomonis*.

Abdomen: Integument dark grayish-brown. Devoid of scales on tergites and sternites I–VII, vestiture of narrow golden hairs similar to those on scutum. Hairs more numerous on posterior segments, grading into narrow curved scales on segment VIII. Cerci with narrow black scales.

ADULT MALE.—In general as in the female. Palpal ornamentation as in *solomonis*. Labium usually entirely dark-scaled. Abdomen as in the female except for numerous yellow scales on tergite VIII. Sidepieces densely covered with yellow scales ventrally and black scales dorsally.

Genitalia: Appear to differ from *lungae* in the following respects: phallosome shorter and broader; clubs on claspettes more slender and not as distinctly enlarged at apex; apical hairs of claspettes shorter, only slightly longer than club, inner accessory hairs shorter than club.

PUPA.—In general as in *solomonis* with the following exceptions. General coloration brownish-yellow; head shield, mesonotum, and metanotum deep brown; trumpet dark yellowish-brown with a preapical line of deep brown pigmentation. Lateral spines of abd. segment V short, acutely tapered, on the same order as those of III and IV, usually one-third as long as those on VI; lateral spines of VI and VII slender, elongate, acutely tapered, without branches or fraying.

LARVA.—Live female larvae are a deep black in color, this intense pigmentation remains particularly in the head capsule, palmate hairs and anal saddle. The male larvae are a dark

reddish-brown except for the black saddle; skins and preserved specimens are also easily recognized by the lighter pigmentation of the head capsule.

Head (Fig. 4): Inner clypeal hairs very long, usually with minute lateral barbs; outer clypeals a third to almost half the length of the inner, usually simple, very rarely with minute barbs; distance between outer and inner hairs one-fourth to one-third that between inner hairs; posterior clypeals long, 2-4-branched, sometimes simple, usually reaching tubercles of anterior clypeals, apical portion of hairs very fine. Frontal and subantennal hairs feathered. Antennae with long spines on inner surface; antennal hair simple, minute, situated one-third the distance from the base; terminal hair longer than sabers, 6-10-branched. Occipital hairs short, inner 2-4-branched, outer 2-5-branched. Head capsule in female completely pigmented a deep brown black, in male incompletely yellowish-brown.

Thorax: Tubercles of prothoracic hairs 1 and 2 (Fig. 5) fused, very rarely one set may be only approximated; hair 1 with heavy flattened shaft and 18-30 branches, branches usually radiating except at apex which may be extended; hair 2 almost twice as long as 1, 12-20-branched, branches more numerous on outer surface; hair 3 small, simple, arising from the fused tubercles. Prothoracic pleural hairs: 9 long, with 4-8 branches; 10 long, simple; 11 about one-third the long hairs, usually simple, occasionally double; 12 long, simple. Mesothoracic pleural hairs: anterior pair (9, 10) long, simple; hair 11 minute, simple; hair 12 approximately one-fourth of long hairs, simple. Metathoracic pleural hairs: 9 usually simple, occasionally double; 10 long, simple; 11 minute, simple; 12 short, 2-4-branched.

Abdomen: Hair 1 on segment I with narrow attenuated, flattened leaflets without serrations, pigmented; hairs 1 on segments II-VII full-sized palmate hairs with broad notched leaflets; 19-25 leaflets on segment III; leaflets (Fig. 3) broad, abruptly narrowed with deep indentations into a delicate terminal filament which is about one-third the length of the shaft; pigmentation heavy and uniform; frequently lateral indentations present on shaft. Hair 2 on segments IV and V simple. Hair 6 of segment IV 2-3-branched; of segment V usually 2, occasionally 3-branched. Anterior tergal plates darkly pigmented, small, half or less the distance between the palmate hairs, except on segment VIII where it is large. Posterior tergal plates very small, present on segments III-VII. Pecten (Fig. 6) with 12-15 teeth, irregularly long, short, and intermediate; larger teeth heavily pigmented, fringed beyond their bases; pecten hair with 6-10 branches. Caudal hooks 6-8. Saddle very heavily pigmented, hair long and simple. Anal gills longer than saddle. Hair 13 of segment V very large, with 8-12 branches.

TYPES.—Holotype ♀, Allotype ♂ with larval and pupal skins, Natalia springs, Poha River Valley, 3 miles south of coast, elevation 200 feet, Guadalcanal, 18 Feb. 1945 (J. N. Belkin). Paratypes: 16 ♀, 6 ♂ with larval and pupal skins, 1 ♂, 18 larvae, same locality as holotype, 10 Dec. 1944, 12-25 Feb. 1945 (J. N. Belkin, M. Cohen, J. J. Cuccio, F. B. Wysocki, E. J. McCormick, Jr.); 2 ♀ with larval and pupal skins, 3 ♀, small tributary of Poha River, 4 miles south of coast, elevation 400 feet, Guadalcanal, 12 Feb. 1945 (J. N. Belkin et al.). Holotype and allotype deposited in U. S. National Museum. Paratypes to be deposited in the collections of Council for Scientific and Industrial Research, Canberra, Cornell University and Johns Hopkins School of Hygiene and Public Health.

Taxonomic position.—*A. nataliae* is a third member of the *lungae* series in group *Neomyzomyia*. It agrees with *lungae* and *solomonis* in palpal, haltere and wing ornamentation and the lack of conspicuous scales on the disc of the scutum in the adult stage, and in the branching of hair 9 of the prothoracic pleural group in the larval stage. The adult female of *nataliae* is separated from the other two species by the extent of light scaling on the labium, the presence of small, broad scales on the fossae, and long narrow scales in front of the wing roots, and the extension of light scales caudad from the central portion of the anterior promontory. The larval stage is immediately recognized by the fused tubercles of prothoracic hairs 1 and 2, the structure of the pecten, the unbranched condition of hair 1 on abdominal segments IV and V, and the extremely heavy pigmentation of the head capsule and anal saddle. In the pupal stage it is intermediate between *lungae* and *solomonis* but can be easily told by the unusual pigmentation of the cephalothorax, trumpets and metanotum, and the structure of the lateral spines on the abdominal segments.

The characters which have been used to separate the species in the *lungae* series are usually clear-cut and quite striking. That these forms are distinct species is

supported by the fact that in a large number of rearings of progenies of wild females of *lungae* and a few *solomonis* no intermediates have been obtained and a remarkable constancy in the specific characters has been observed. Except for the labial ornamentation and some of the features of the pupa the specific characters of *nataliae* are in no way intermediate between *lungae* and *solomonis*, but represent an entirely different line of specialization. The greater extent of scaling of the lateral and anterior portions of the scutum in *nataliae* shows closer relationship to the *punctulatus* series than is exhibited by *lungae* or *solomonis*.

Biology.—To date *A. nataliae* has been collected in two areas more than a mile apart in the Poha River valley a short distance downstream from its entrance into the coastal coral foothills from the igneous formations of the Kavo Range. Whether these localities are normal breeding places or represent small colonies established following flushing from breeding places upstream remains to be determined. Both breeding places are seepage and spring areas with clear running water and are densely shaded. The larvae and pupae are very scarce and difficult to collect because of their habit of resting on top of floating vegetation and debris or on the margins of the creeks, usually where the current is fairly swift. The larvae are extremely active and appear to rest normally parallel to an object rather than at right angles to it as is the case with most anophelines. In the laboratory the pupae behave as those of *lungae* and *solomonis* as they usually rest above the water surface and the adults emerge from this position.

Bironella hollandi, *A. solomonis*, *farauti* and *lungae* have been collected with *nataliae* in the order of their abundance.

The larvae of *nataliae* in life have the short broad appearance characteristic of the *lungae* series. They differ from *solomonis* and *lungae* in their opaque bodies. The female larvae have coal-black bodies with densely pigmented black head and saddle and are easily distinguished from male larvae which have reddish-brown bodies, dark brown heads, and black saddle.

Adults have not been collected in nature.

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EXPLANATION OF PLATE

Anopheles nataliae, n. sp.

- FIG. 1. Adult female. Head, proboscis and palpus.
FIG. 2. Adult female. Buccopharyngeal armature.
FIG. 3. Larva. Leaflet of palmate hair, abd. III.
FIG. 4. Larva. Anterior portion of head.
FIG. 5. Larva. Prothoracic submedian group, right side.
FIG. 6. Larva. Pecten, left side.

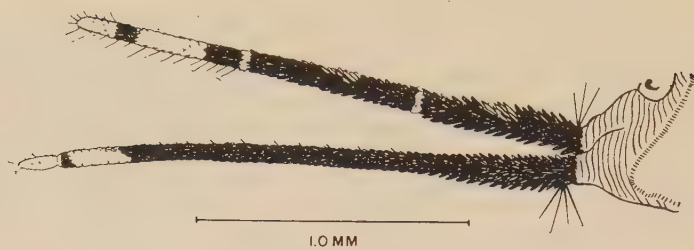


FIG. 1

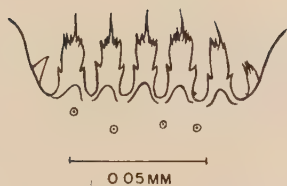


FIG. 2

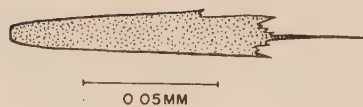


FIG. 3

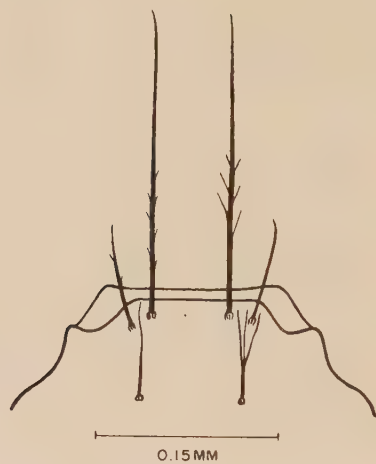


FIG. 4



FIG. 5



FIG. 6

LABORATORY REARING AND LIFE CYCLE OF *PHLEBOTOMUS*
(*DAMPFOMYIA*) *ANTHOPHORUS* ADDIS (DIPTERA:
PSYCHODIDAE)¹

C. J. ADDIS

The author (1945) described *Phlebotomus (Dampfomyia) anthophorus* from specimens collected at Uvalde, Texas, and published notes on the biology and habits of the adult female in nature. The female flies were captured while feeding on rabbits in the mornings and shipped to Houston, where a simple and practical method of rearing a large number of the flies in the laboratory was employed.

Several methods for rearing sandflies have been described (Whittingham and Rook, 1922; Waterston, 1922; Smith, 1925; Christophers, Shortt, and Barraud, 1926; and Adler and Theodor, 1935), but all of them require much attention in order to maintain the correct amount of moisture. Nájera (1941) used filter paper cups fitted into vials, and moisture supplied by a wick-like arrangement. We tried this method but difficulty was encountered in preventing moisture from condensing on the sides of the vials, which caused the death of the flies. We remedied this somewhat by cutting off the upper end of the vial and covering it with muslin, but the keeping of the flies in individual vials made this method impractical for the rearing of a large number of flies.

In the rearing of sandflies it is necessary to keep the flies at a temperature of 28–29° C and to maintain a high humidity in the breeding chambers without condensation of moisture.

In our laboratory a breeding chamber (Fig. 5) was constructed in which the flies passed through all stages of development without any further change in the apparatus. In preparing the chamber an earthenware saucer 6 inches in diameter and about 1½ inches deep was filled with plaster of Paris to a depth of about 1 inch. A ring of paraffin was poured over the surface of the plaster of Paris except for a space in the center about 3 inches in diameter, and a lantern globe 3½ inches in diameter at the base and 7 inches in height was pressed firmly into the paraffin over this central space. The upper end of the lantern globe was covered with muslin and the entire chamber set in a tray of water. The trays were then placed in an incubator maintained at a temperature of 28° C.

The flies were captured in small vials plugged with cotton moistened with sugar water. For shipping, a cigar box was prepared by cutting several holes in the sides and bottom, and by placing a piece of hardware-cloth about an inch from the bottom. The vials were placed in a wet cloth bag and then spread evenly over the hardware-cloth. Damp cotton was laid over the top of the vials to protect them in transit. On reaching Houston at night, the flies were at once released into a feeding cage a cubic foot in size, closely lined with muslin, and given an opportunity to feed on a hamster enclosed in a hardware cloth cylinder measuring 5 × 3 × 3 inches.

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¹ The work described in this paper was done under a contract, recommended by the Committee on Medical Research, between the Office of Scientific Research and Development and the Rice Institute, Houston, Texas. The author wishes to express his appreciation to Dr. Asa C. Chandler for his advice and aid, and to Mrs. Evelyn Hake for the preparation of the slides.

When examined between 8 and 9 AM very few flies had fed, but by noon practically every fly which showed no signs of a previous blood meal had fed. The feeding of the caged flies during the morning coincides with the observations of the writer (1945) on the adults in nature. The females, after engorging, were placed in the breeding chambers.

After oviposition the eggs were counted and food for the larvae was spread on the surface of the plaster of Paris. The first food mixture we tried consisted of dried rabbit feces and blood, but the mature larvae failed to pupate over a period of 2 months. When a few drops of fluid containing all the known components of the vitamin B complex were added to the food, pupation occurred within 3 days. Later we tried a mixture of rich garden earth and rabbit blood, which gave satisfactory results without the addition of vitamins, and was finally used exclusively. This medium was prepared by adding rabbit blood to the finely ground garden earth until it had the consistency of a thick paste. The mixture was then dried, ground into a powder, and kept in glass jars until used. The food material was spread unevenly over the surface of the plaster of Paris so that there was a gradation from very moist areas to practically dry areas. The correct amount of moisture can easily be judged by looking at the medium under a binocular; if a film of water is observed, the medium is too wet and should be corrected by increasing the thickness of the plaster of Paris in the saucer. A mold and small mites appeared in some of the saucers, but apparently had no harmful effect on the development of the flies.

After pupation the chambers were watched closely for the appearance of adults. These were at once transferred to another chamber with a piece of cotton soaked with sugar water on the floor. After 2 to 3 days the flies were released into a feeding cage and allowed to take a blood meal. After feeding the flies were put back into the breeding chambers and left until oviposition or death.

This method proved highly efficient in our work with *Phlebotomus anthophorus* and could probably be adapted to the rearing of other species of sandflies. However, when the same procedure was used for the rearing of *P. diabolicus*, the larvae, although they grew to maturity satisfactorily, failed to pupate, even when a mixture of the known B vitamins was added to the food. It would appear from this, that the accessory food factors required for pupation vary with different species of *Phlebotomus*.

LIFE CYCLE

The following observations on the life cycle of *Phlebotomus anthophorus* were made on 6 different groups of 12 flies kept at a temperature of 28 to 29 degrees C and at a constant humidity. The food for the larvae consisted of the garden earth and rabbit-blood mixture described above. The average time for each developmental stage is given in parenthesis.

The engorged females, kept in the breeding chambers and allowed to feed on sugar water, oviposited within 3 to 6 (4.7) days after taking a blood meal. The eggs were deposited on the surface of the plaster of Paris in clusters of 5 or 6, or singly, with as many as 20 eggs being deposited by one female. The freshly deposited eggs are a light tan in color, turning a dark brown after a few hours, with irregular light striations over the surface (Fig. 1). The eggs are elongate, somewhat smaller at one end, and measure 373–403 (381) microns in length and 119–134 (126) microns in the greatest width.

The incubation periods ranged from 9 to 14 (10.5) days. The newly hatched larvae are white in color and have 2 caudal setae. After the first molt the larvae turn darker in color, having a dirty appearance, and have 4 caudal setae (Figs. 2 and 3). The larvae were observed feeding on the medium and moving about slowly in a characteristic looping movement. While young they favored the more moist areas of the medium, but towards the end of the larval stage they migrated towards the drier places to pupate.

Pupae (Fig. 4) appeared within 22 to 38 (28.4) days after the hatching of the larvae, and adults emerged within 8 to 10 (8.7) days after pupation. The developmental period from the laying of the eggs to the emergence of the adults required 40 to 60 (49) days.

The females took blood meals within 2 to 4 (3) days after emerging and lived for 4 to 9 (6) days in the breeding chambers after the blood meal. During this time the flies were maintained on raisins, and one fly took a second blood meal on the eighth day. The total length of life for the emerged females was 8 to 11 (9.2) days and for the males 4 to 8 (5.3) days.

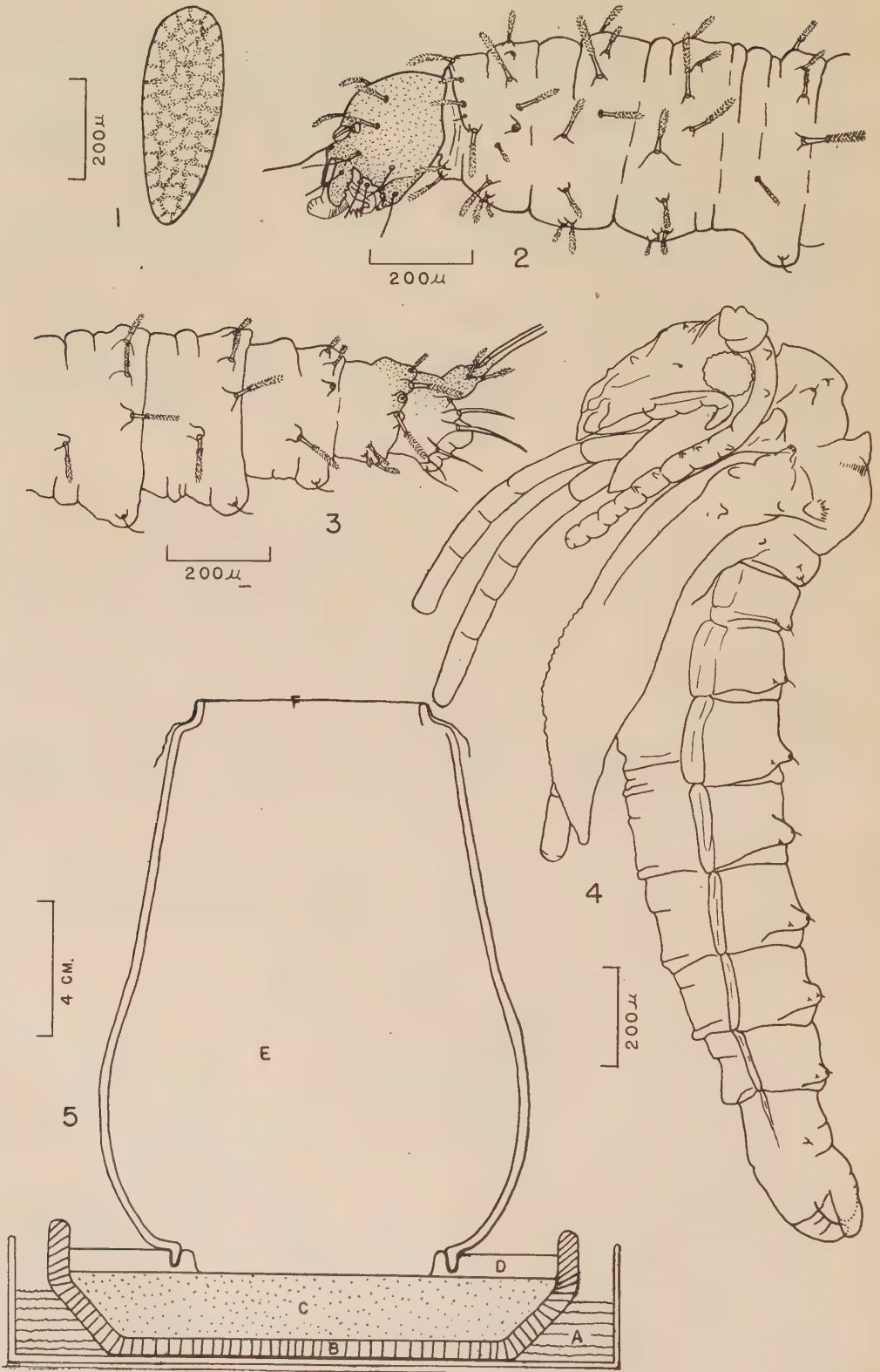
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EXPLANATION OF PLATE

Phlebotomus (Dampfomyia) anthophorus Addis

- FIG. 1. Egg.
- FIG. 2. Head and thorax of fourth stage larva.
- FIG. 3. Posterior end of fourth stage larva.
- FIG. 4. Pupa.
- FIG. 5. Diagram of breeding chamber.
- A. Water
 - B. Earthenware saucer
 - C. Plaster of Paris
 - D. Paraffin
 - E. Lantern globe
 - F. Muslin



THE GENUS *DISPHARYNX* (NEMATODA: ACUARIIDAE) IN GALLIFORM AND PASSERIFORM BIRDS

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Commonly listed as a parasite of poultry (Mönnig, 1938; Barger and Card, 1938; Wehr, 1943) is the proventricular worm *Dispharynx spiralis* (Molin, 1858) Skrjabin, 1916. Parasitological examinations of poultry in North America, however, have shown that its presence in domestic birds in this part of the world is rare.

Autopsies of certain wild gallinaceous birds, on the other hand, have revealed relatively high incidence of the parasite. Its demonstrated presence in several species of perching birds and a comparative study of the form from several different hosts has pointed to the possibility that most of the specimens of *Dispharynx* from galliform and passeriform birds in both hemispheres belong to the same species. It is the purpose of this article to record observations on the proventricular worms of this genus which we have encountered and to discuss the probable identity of the forms reported from the above mentioned birds.

HISTORICAL

Rudolphi (1819) described *Spiroptera nasuta* from the proventriculus of the house sparrow (*Passer domesticus*) from Vienna. In 1844 ("1845"), Dujardin encountered the same form in sparrows in Paris. He erected the genus *Dispharagus* and included Rudolphi's form in it, as *D. nasutus* (Rud. 1819). Since *Dispharagus* was a renaming of a group of species for which two generic names were already in existence, and included the type of the genus *Acuaria* Bremser, 1811, it subsequently fell into synonymy with the latter genus (see Cram 1927a).

Diesing (1851) reported *S. nasuta* from domestic fowl (*Gallus gallus*) in Austria. Subsequently Casali (1874), Colucci (1893), and Piana (1897) recorded it from fowl in Italy; LeGros (1864), Neumann (1892), and Rabieaux (1900) from France; Johnston (1912), from Australia; Purvis (1913) from Washington and Oregon; Ransom (1916) from Guam as *Cheilospirura nasuta*. It has also been listed from Belgian Congo (Cram 1927a).

Molin (1858) found proventricular worms in the domestic fowl in Italy which he described as a new species, *Dispharagus spiralis*. Also recorded as *D. spiralis* were worms from Guinea fowl (*Numida meleagris*) in Italy (Stossich, 1891) and pigeon (*Columba livia*) in Tunisia (Bridré, 1910).

In 1912 Railliet, Henry and Sisoff, revised the genus *Acuaria* Bremser, 1811, erecting the subgenus *Dispharynx*, with *A. (D.) nasuta* (Rud., 1819) as the type species, including also *A. spiralis* (Molin, 1858) and three species from falconiform birds. Without giving their reasons they expressed the opinion that all the records of *A. nasuta* from galliform and columbiform birds were in reality reports of *A. spiralis*. They may have been influenced by the fact that the only records of *Dispharynx* in passeriform birds to that date were those of Rudolphi (1819) and Dujardin (1844).

Seurat (1916) recorded *A. spiralis* from a partridge (*Alectoris barbara*) in Algeria, and listed (without details or reference) the pheasant as a host of the parasite. In the same year Skrjabin, who raised the sub-genus *Dispharynx* to generic rank, recorded it from chickens in Russian Turkestan. Recent old world reports are those of Gushanskaia (1937) who found it in *Coracias garrula* in Uzbekistan and Kazakhstan, and Madsen (1941) who encountered it in partridges (*Perdix perdix*) and pheasants (*Phasianus colchicus*) in Denmark.

Since Walton (1923) reported *A. spiralis* in this country from the bronzed grackle (*Quiscalus versicolor*) in Illinois, the form commonly designated as *Dispharynx spiralis* (Molin, 1858) Skrjabin, 1916 has been reported from a number of localities and hosts in North America.

Its pathogenicity for the Ruffed Grouse (*Bonasa umbellus*) was first pointed out by Allen (1924) who described and pictured the proventriculitis caused by its presence. It has been listed from this host in New York (Allen, 1924), Maine and Connecticut (Gross, 1925), Massachusetts, Rhode Island and New Jersey (Allen and Gross, 1926), New Hampshire (Gross, 1930), Nova Scotia (Gross, 1931), and Michigan (Fisher, 1939).

The parasite has also been reported from several other game birds: sharp-tailed grouse (*Pedioecetes phasianellus*) in Wisconsin (Gross 1931); bobwhite quail (*Colinus virginianus*) in Virginia (Cram, 1931a), North Carolina (Moore, 1933) and Ohio (Venard, 1933); Hungarian partridge (*Perdix perdix*) in Wisconsin (Cram, 1931b) and Ohio and Michigan (Yeatter, 1934); ringnecked pheasant (*Phasianus colchicus*) and golden pheasant (*Chrysolophus pictus*) in New York (Goble and Cheatum, 1943).

To our knowledge the only recent records from domesticated galliformes in North America are those of Cram (1927b, 1932c); Guinea fowl (*Numida meleagris*) from Puerto Rico; domestic fowl (*Gallus gallus*) from Louisiana; turkey (*Meleagris gallopavo*) from Maryland. There are, however, in addition to Walton's record from the bronzed grackle, a number of reports of this nematode from passeriform birds: house sparrow (*Passer domesticus*) from the District of Columbia (Cram, 1932a); robin (*Turdus migratorius*) from New Jersey (Cram 1932a) and New York (Webster 1943); catbird (*Dumetella carolinensis*) from New Jersey (Cram 1932b); Carolina wren (*Thryothorus l. ludovicianus*) from Texas (Harwood, 1933). Both Cram (1928) and Wehr (1943) have observed the parasite in pigeons (*Columba livia*) from Texas and California, respectively.

During the decade 1932-1941 inclusive, over 2800 specimens of ruffed grouse (*Bonasa umbellus*) were examined in the Pathological Laboratory, Bureau of Game, New York State Conservation Department. The results of these examinations were recorded by Levine and Goble (Unpublished MS, prepared 1942). Their salient conclusions may be summarized briefly: (1) In the areas in which it occurs, *Dispharynx* is the most important helminth parasite of ruffed grouse. (2) It occurs in about one-third of the birds-of-the-year examined during the fall and winter. During the same seasons, only about one-seventh of the adults are infected. (3) The proventriculitis which usually accompanies the infections is often severe and sometimes fatal. (4) The parasite has not been found in the Adirondack region in New York and is apparently absent from the northern forests in other states as well, although Oniscoidea, the only reported intermediate hosts (Cram, 1931b) are present in those areas.

MATERIALS

The hosts examined for proventricular worms are listed in Table 1. The galliforms were submitted to the laboratory at various times between 1938 and 1945. The small numbers of bobwhite quail and Hungarian partridge examined are a reflection of their relative scarcity in most of upper New York State. All birds listed were from the wild with the exception of the peafowl which was a domestic inhabitant of the Union College Campus at Schenectady.

The passeriform birds were collected by various means during the period of March through December, 1944. Some were shot, some were trapped, others were victims of predation or accidental trauma. The species collected represent a

TABLE 1.—Occurrence of *Dispharynx* in birds in New York

Hosts	Juveniles			Adults		
	Examined	Infected	Per cent	Examined	Infected	Per cent
Galliformes						
Ruffed grouse (<i>Bonasa umbellus</i>)	301	102	34	303	40	13
Ringnecked pheasant (<i>Phasianus colchicus</i>)	203	2	1	937	0	0
Peafowl (<i>Pavo cristatus</i>)	0	0	0	1	1	100
Hungarian partridge (<i>Perdix p. perdix</i>)	9	2	22	33	2	7
Eastern bobwhite (<i>Colinus v. virginianus</i>)	0	0	0	2	1	50
Passeriformes						
Eastern crow (<i>Corvus b. brachyrhynchos</i>)	12	2	18	25	0	0
Catbird (<i>Dumetella carolinensis</i>)	1	1	100	1	0	0
Eastern robin (<i>Turdus m. migratorius</i>)	20	6	30	55	1	2
Eastern bluebird (<i>Sialia s. sialis</i>)	5	2	40	31	4	13
Starling (<i>Sturnus v. vulgaris</i>)	40	4	10	78	2	3
House sparrow (<i>Passer d. domesticus</i>)	23	1	4	27	0	0
Eastern cowbird (<i>Molothrus a. ater</i>)	18	5	28	48	4	8

The following numbers of other passeriform birds have been examined for *Dispharynx* and found negative: Bobolink (*Dolichonyx oryzivorus*)—20; eastern meadowlark (*Sturnella m. magna*)—24; eastern redwing (*Agelaius p. phoeniceus*)—39; bronzed grackle (*Quiscalus versicolor*)—44; slate-colored junco (*Junco h. hyemalis*)—22; eastern tree sparrow (*Spizella a. arborea*)—20; eastern song sparrow (*Melospiza m. melodia*)—26.

haphazard sample of the common forms which occur in the vicinity of several game farms and refuges in upper New York State. One specimen, the catbird, was found sick and picked up by hand.

Birds listed as juveniles were those in which the *bursa fabricii* was still present. No passeriforms were collected after December, so probably most of the juveniles were less than 6 months old. Grouse, however, were taken during all months of the year and since the *bursa* persists into the winter in grouse, some of the birds recorded as juveniles were as old as 9 months.

Specimens of *Dispharynx* collected from the proventriculi of the listed species of birds were fixed in hot 70 per cent alcohol with 5 per cent glycerin, and were examined either in glycerin, after the evaporation of the alcohol, or in lactophenol. The number of worms available for morphological study is indicated in Table 3. Not listed individually therein are the infections in ruffed grouse, from which abundant *Dispharynx* material was obtained.

INCIDENCE

The incidence of *Dispharynx* in the galliform and passeriform birds examined is indicated in Table 1. To our knowledge, proventricular worms of this genus have not previously been reported in the peafowl, crow, bluebird, starling or cowbird. In pheasants, where the occurrence was extremely rare, the only infections were in chicks from one limited area.

The large number of ruffed grouse examined permitted a more detailed breakdown of the data as to age and season. These data are presented in Table 2. In the collection of grouse chicks from three summers, the earliest date on which *Dispharynx* infection was observed was July 20 and the smallest (youngest) bird in which it appeared weighed 144 grams (about 5 weeks old). Eliminated from the data used in determining incidence, therefore, were all grouse weighing less than 144 grams or taken before July 20th as well as those taken in areas where large collections have revealed no infections and where the parasite apparently is

TABLE 2.—Incidence of *Dispharynx* infection in grouse, indicating ages of birds, seasons and fatality of infections

Ages of birds	Season	Number examined	Number infected	% infected	Number fatalities	% of infected cases fatal
Juveniles (less than 3 mo. old)	Summer	115	35	30.4	1	
Juvenile (3-6 mo. old)	Fall	158	61	38.6	26	
Juvenile (6-9 mo. old)	Winter	28	6	21.4	4	
Total		301	102	33.8	31	30.3
Adult (over 9 mo.)	Spring	56	8	14.3	5	
Adult (over 12 mo.)	Summer	90	7	7.8	2	
Adult (over 15 mo.)	Fall	98	15	15.3	2	
Adult (over 18 mo.)	Winter	59	10	16.8	4	
Total		303	40	13.2	13	32.5

not enzootic in grouse (i.e., the Adirondack region). Thus the figures given are a good estimate of the incidence to be expected in birds old enough to be infected in parts of the state where the parasite is known.

The incidence in juvenile grouse is significantly greater than in adults in both the summer and fall seasons, but the fluctuations in incidence from season to season are not significant. Higher susceptibility of young animals to infection is a generally accepted principal in parasitology, but little seems to have been recorded on this subject with reference to *Dispharynx* infections. Madsen (1941) observed that in partridges in Denmark the parasite "was encountered most often and in the largest numbers in young adult birds," and that in pheasants *Dispharynx* "appeared only in chicks and the infections were light." The available information on the occurrence of the worm in passeriforms seems to indicate the same differences in incidence due to age of host.

SIZE OF INFECTIONS

The number of worms encountered in infected birds is shown in Table 3. Omitted from this table are the records of worms from grouse, which are so numerous as to require an inordinate amount of space; the information can be adequately presented as averages. The average number found in both juvenile and adult grouse in which no gross proventriculitis was observed was 9. The

scopic leucocytic infiltration and congestion at the point of attachment of the worms to severe chronic catarrhal proliferative proventriculitis in which the saccular stomach is enlarged to several times its normal size and the lumen is plugged with a necrotic mucous mass of sloughed and sloughing epithelium.

In general, the degree of inflammation of the proventriculus was observed to be proportional to the size of the infections. This is confirmed by data from examinations of ruffed grouse. On autopsy, the degree of proventriculitis, when present, was recorded as slight, moderate or severe (+, ++, +++). The total number of worms present was also recorded for each examination. Of 30 grouse for which these data were available 10 showed slight proventriculitis, 10 moderate, and 10 severe. The number of worms found in the first group ranged from 10 to 27 (average 18); in the second group 18 to 109 (average 50); in the third group 70 to 246 (average 132).

At post-mortem examination of the 604 ruffed grouse listed, an estimation was made as to the probability of fatality of the *Dispharynx* infections observed, regardless of the immediate cause of death. Some of the birds were actually found dead in the wild, some were sick and readily taken alive, subsequently dying in captivity; others were caught by hunting dogs or predators, still others were killed by automobiles or shot by hunters and collectors.

Of the 102 infected juvenile grouse 31 (30.3 per cent) either died as a result of the infection or were considered seriously enough affected so that death would have resulted soon had they not been collected by one of the above-mentioned means. Of the 40 infected adults 13 (32.5 per cent) were considered to be fatally infected. No similar information could be adduced for the passerine birds. The catbird was the only one collected which was obviously adversely affected by its *Dispharynx* infection.

MORPHOLOGY

Morphological examination of specimens of *Dispharynx* from the species listed revealed their identity with the form commonly known as *Dispharynx spiralis* (Molin, 1858) Skrjabin, 1916. Measurements on the worms all fell within the limits indicated by Cuvillier's (1937) studies and it is felt that little purpose would be served by amplification of her table of measurements.

The vulva was, in all cases, in the posterior part of the body, as described by Molin (1858) for *D. spiralis* and by Piana (1897) for *D. nasuta*. Since the position of the vulva is the only character consistently proposed for the separation of the above-mentioned species, the situation prevailing in all of our material from both passeriform and galliform birds is mentioned here in anticipation of the discussion which follows concerning the probable conspecificity of the two species.

DISCUSSION

The conclusion that all the forms of *Dispharynx* recently recorded from galliform, columbiform and passeriform birds in the Western Hemisphere are conspecific leads to the consideration of the identity of the helminths reported as *Dispharynx nasuta* (Rudolphi, 1819) Stiles and Hassall, 1920, originally described from the house sparrow in Vienna and later recorded from chickens in Europe, Australia, and North America.

A survey of the literature on *Dispharynx* reveals that the only substantial character proposed to distinguish *D. spiralis* from *D. nasuta* is the position of the vulva. Rudolphi's (1819) description did not indicate whether the vulva was located in the anterior or posterior part of the body. Dujardin (1844), however, stated its position to be anterior and his description has been followed by many subsequent authors, none of whom, it is apparent, ever observed at first hand *Dispharynx* material from passerine birds (Molin, 1860; Stossich, 1891; Neveu-Lemaire, 1912).

When Diesing (1851) reported *Spiroptera nasuta* from the chicken for the first time he did not mention the position of the vulva, but he did place a question mark after the name *Dispharagus nasutus* Dujardin which may indicate that he questioned some part of Dujardin's description in the light of his material. Subsequently Molin (1858) found a *Dispharynx* in the chicken and described it as *D. spiralis*, indicating the position of the vulva to be in the posterior part of the body.

Apparently the only investigator who has reported *Dispharynx* females with the vulva anterior is Dujardin and there is no modern work indicating this morphological character in worms of this genus from passiformes, galliformes or columbiformes. Yorke and Maplestone (1926) give an original figure of *D. nasuta* showing the vulva to be posterior. In our opinion, it is highly probable that Dujardin's observations on this point were erroneous.

The records of *D. spiralis* from the type host of *D. nasuta*, the cosmopolitan distribution of both species, and their morphological identity seem to be legitimate reasons for considering *Dispharynx spiralis* (Molin, 1858) Skrjabin, 1916 to be a synonym of *Dispharynx nasuta* (Rudolphi, 1819) Stiles & Hassall, 1920, which has priority by 39 years.

Dispharynx nasuta (Rudolphi, 1819) Stiles & Hassall, 1920

Synonyms: *Spiroptera nasuta* Rudolphi, 1819; *Dispharagus nasutus* (Rudolphi, 1819); Dujardin, 1844; *Dispharagus spiralis* Molin, 1858; *Filaria nasuta* (Rudolphi, 1819) Schneider, 1866; *Dispharagus tentaculatus* Colucci, 1893; *Dispharagus spiralis columbae* Bridré, 1910; *Acuaria (Dispharynx) nasuta* (Rudolphi, 1819) Railliet, Henry & Sisoff, 1912; *Acuaria (Dispharynx) spiralis* (Molin, 1858) Railliet, Henry & Sisoff, 1912; *Cheilospirura nasuta* (Rudolphi, 1819) Ransom, 1916; *Dispharynx spiralis* (Molin, 1858) Skrjabin, 1916; *Dispharynx stonae* Harwood, 1933.

Hosts: Passeriformes: *Passer domesticus* (type host), *Corvus brachyrhynchos*, *Coracias garrula*, *Thyrothorus ludovicianus*, *Dumetella carolinensis*, *Turdus migratorius*, *Sialia sialis*, *Sturnus vulgaris*, *Quiscalus versicolor*, *Molothrus ater*. Galliformes: *Meleagris gallopavo*, *Numida meleagris*, *Pavo cristatus*, *Perdix perdix*, *Alectoris barbara*, *Colinus virginianus*, *Phasianus colchicus*, *Gallus gallus*, *Chrysolophus pictus*, *Bonasa umbellus*, *Pedioecetes phasianellus*. Columbiformes: *Columba livia*.

Geographical Distribution: Europe: Austria (type locality), France, Italy, Spain, Denmark. Asia: Russian Turkestan, Uzbekistan, Kazakhstan. Africa: Tunisia, Algeria, Belgian Congo. North America: Puerto Rico, United States (New England, New York, New Jersey, Maryland, District of Columbia, Virginia, Ohio, Michigan, Illinois, Wisconsin, Louisiana, Texas, California), Canada (Nova Scotia). South America: Brazil. Australia. Guam.

SUMMARY

The incidence of proventricular nematodes of the genus *Dispharynx* in galliform and passeriform birds in New York State is given. Records from peafowl, crow, bluebird, starling, and cowbird are probably new. Data indicate significantly higher incidences in juveniles than in adults.

Observations are made on the size of infections and the pathologies attributable to the presence of the parasites. Tissue changes were, in general, proportional to the size of the infections. A little less than a third of the ruffed grouse examined were considered to have died as a result of parasitosis by *Dispharynx* or were so seriously affected that death was inevitable.

Morphologic and taxonomic features of the parasites are discussed and reasons set forth for considering *Dispharynx spiralis* (Molin, 1858) Skrjabin, 1916, to be a synonym of *Dispharynx nasuta* (Rudolphi, 1819) Stiles and Hassall, 1920. Synonymy, host records and geographical distribution are given.

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THE ACANTHOCEPHALAN GENUS *CORYNOSOMA*. I. THE SPECIES FOUND IN WATER BIRDS OF NORTH AMERICA

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Individuals of the acanthocephalan genus *Corynosoma* reach sexual maturity in the digestive tract of birds and mammals, especially those in aquatic habitats or those feeding on fish or aquatic invertebrates which serve *Corynosoma* as intermediate hosts. Although the same species has often been reported from both aquatic birds and mammals, Lundström (1941) has recently reviewed the evidences which seem to discount the possibility that both of these host groups serve as normal host to the same species of *Corynosoma*. In observations on the two best known representatives of the genus in Europe, *Corynosoma strumosum* and *C. sermerme*, Lundström's results support those earlier announced by Forssell (1904, 1905). Both of these species are normal parasites in the intestine of fish-eating mammals, especially seals. Although both species likewise occur often in the intestine of water birds they never attain full functional maturity in these hosts. Larvae of these two species, in the bodies of fish, may be introduced into the digestive tract of birds that prey upon fish but the worms fail to prosper there sufficiently to bring their eggs to full maturity. Evidence of this sort constitutes one of the most valid indictments of the meaningless expansions of "host lists" which received so much attention on the part of parasitologists, particularly a generation ago.

An analysis has been made of numerous collections of *Corynosoma* from various parts of North America. On this continent there are some species which normally parasitize birds and other species which infect mammals. There are no clearly marked evidences of infections occurring in the alternative host group such as have been found for the European species. In the present paper, only those species which infect water birds of North America will be considered. One of these is a well known species, *Corynosoma constrictum* Van Cleave, 1918; the other is a new species here described as *Corynosoma anatarium* n. sp.

Other taxonomic and morphological studies on *Corynosoma* are in the course of preparation for publication.

In 1918, the writer described and named *Corynosoma constrictum*, the first valid species of the genus to be recorded from North American water birds. The material upon which the description was based had been collected by Dr. Edwin Linton from the intestine of the American scoter (*Oidemia americana* Swainson) on Yellowstone Lake in Wyoming. Dr. Linton (1892) had mistakenly identified the worms as "*Echinorhynchus striatus* Goeze" a species described from European water birds. The specific identity and generic assignment of this European species were long under discussion (Lühe, 1911) although Meyer (1931, 1932-3) more recently ascribed it to the genus *Polymorphus*. As pointed out by the present writer in 1918, the males of Linton's original specimens had conspicuous cuticular spines on the fore body (Fig. 10) and around the posterior extremity in the region of the genital pore. This last statement alone is proof of the fact that the individuals are of the genus *Corynosoma*. The genital spines were shown clearly in Linton's

drawings (1892, figs. 18–20) and were likewise recognized by the present writer when he reexamined the original material (see Fig. 9).

Since 1918, the writer has examined many hundreds of specimens of *Corynosoma constrictum* which had been submitted for identification by numerous colleagues. As a result of these studies, *C. constrictum* is now known from at least 10 different host species and from 11 states in addition to records from British Columbia.

Until the life history of this parasite is established, the ecological and economic importance in any given habitat cannot be determined. In many of the localities here recorded, the ducks were killed during their migration. It is consequently uncertain whether their parasites have become established in the region where the infected birds were taken. It is thus possible that *C. constrictum* might be only a seasonal migratory intrusion into the habitats frequented by its migratory hosts. There is no evidence available for establishing any regions as foci for infection by *C. constrictum* and such evidence will in all probability continue to be lacking until the life history of the species becomes known. Broad geographical distribution of this parasite might be dependent upon very extensive geographical distribution of infected intermediate hosts or on the contrary it might be due to wide migratory dispersal of the definitive bird hosts from a very restricted area in their winter habitat where they are exposed to infected intermediate hosts.

Dispersal of parasites in the bodies of migratory birds, even though the infection might have been acquired on another continent, offers opportunity for ultimate extension of geographical range of the parasite. In the numerous localities visited by the infected migratory birds, the opportunity for embryos of the parasitic worms to become established in local arthropods is always present. By this means, parasites transported from a distance by migratory water fowl become potential threats to the native birds and to domestic water fowl.

The following table shows the geographical distribution and the hosts of *Corynosoma constrictum* in the collections of the writer.

Host*	Locality	Collector
"Domestic duck"	Illinois	N. D. Levine
	Illinois	E. Bushing
"Teal"	New Jersey	F. R. Beaudette
	North Dakota	H. B. Ward
<i>Anas platyrhynchos platyrhynchos</i> (mallard)	Illinois	W. C. Starrett
	Iowa	H. J. Griffiths
	British Columbia	C. J. Spencer
<i>Dafila acuta tzitzihua</i> (pintail duck)	Illinois	W. C. Starrett
	Wisconsin	W. Olson
	Michigan	W. C. Gower
	British Columbia	C. J. Spencer
<i>Erismatura jamaicensis rubida</i> (ruddy duck)	Illinois	W. C. Starrett
	Iowa	H. J. Griffiths
	Ohio	R. Rausch
	Oklahoma	J. E. Guberlet
<i>Fulica americana</i> (American coot)	Ohio	R. Rausch
<i>Nettion carolinense</i> (green-winged teal)	Illinois	W. C. Starrett
	Texas	E. W. Price
	Iowa	H. J. Griffiths
<i>Nyroca affinis</i> (lesser scaup duck)	British Columbia	C. J. Spencer
<i>Nyroca</i> sp? (scaup duck undet.)	Iowa	H. J. Griffiths
<i>Oidemia americana</i> (American scoter)	Wyoming	E. Linton
<i>Querquedula discors</i> (blue-winged teal)	Oklahoma	J. E. Guberlet
	North Dakota	L. B. Dickey
	British Columbia	C. J. Spencer
<i>Spatula clypeata</i> (shoveller)	Iowa	H. J. Griffiths

* Kortright's convenient handbook has been accepted as authority for host names. In some instances, the name that he uses is different from the one accepted by Peters (1931) in his comprehensive catalog of the birds of the world.

In connection with the records shown in the foregoing table, attention should be called to the fact that many of the individual entries of a host from a given locality represent a considerable number of host individuals. In distribution of the sort shown here, where a species utilizes as definitive host various species over a very broad geographical range, the calculations of percentages of infection and records of negative findings are without particular significance and negative records will not be cited. Apparently there is no specificity in host relations for *Corynosoma constrictum*. The chance for any individual of several host species to carry this parasite seems to depend almost wholly upon the availability of food infected with the larvae. The intermediate host of hosts for *C. constrictum* are not known. The diversity in habits, food habits and habitats of the recorded definitive hosts makes it seem probable that some arthropod, particularly a crustacean, is the intermediate host. Food habits of the definitive hosts make it seem doubtful whether fishes serve as reservoir hosts for this species as they do for some of the European members of *Corynosoma*.

It should be noted that in preparing the foregoing table there has been no attempt to determine the synonymy for earlier North American literature records of acanthocephalans in ducks. The obvious misidentification of the original material on which *C. constrictum* is founded, as a European species of an entirely different genus, gives evidence of the futility of any attempt at determining synonymy when the original material is not available.

The writer is deeply indebted to the numerous investigators mentioned in the table for their cooperation in sending material for identification. This is the first of a projected series of articles dealing with the acanthocephalan fauna of North American water birds. The writer expects to complete further studies in the near future giving details of distribution for other species of acanthocephalans of birds. The numerous species of the genus *Polymorphus* are particularly abundant in collections received from these and other collaborators.

The scarcity of records of *Corynosoma* from North American birds in the literature is reflected in the fact that Gower (1939) in his host-parasite catalog of worm parasites of ducks of the world entered only the type host, *Oedemia americana*, as host of *C. constrictum*. At least one other host had escaped Gower's attention since the blue-winged teal (*Querquedula discors*) had been recorded previously as host for this parasite (Van Cleave, 1920). In an earlier paper, Gower (1938) recorded the results of an examination of 104 individuals representing 12 species of ducks, all from Michigan. Although these species included practically all of the species of ducks reported as hosts for *Corynosoma* in the present paper, he gave no record of encountering that genus although 7.7% of the individuals were infested by the acanthocephalan genus *Polymorphus*, which he erroneously called *Filicollis*. The 11 genera of worms for which Gower presented data might not have been all the genera which he encountered, since he made no statement whether he included all forms found or selected only certain groups for comparison. It would at least seem probable that if *Corynosoma* were present in his collections it must have been less well represented than *Polymorphus*.

In 1940, Van Cleave and Starrett listed a total of six species of ducks as host for *C. constrictum*, all from Illinois. All of the earlier records are incorporated in the table here given.

The significance of the genital spines in the taxonomy of *Corynosoma* has been

treated in detail in another paper now in press. In that contribution the writer has demonstrated, for the first time, that a secondary introversion of the hind body in *Corynosoma* may completely conceal the genital spines by withdrawing them, inside the introverted genital vestibule, to a position entirely within the body. No conspicuous instances of genital vestibule formation have been observed for specimens of *C. constrictum*, hence the genital spines are usually readily visible for generic determination, especially in the males. However, the genital spines in females of this species are often very diminutive (Figs. 5, 6) and consequently are not easily seen. This is particularly true when cleared specimens are examined without staining. Furthermore, it is obvious that the genital spines of many female individuals become completely lost (Fig. 7) when the copulatory cap is shed, as first demonstrated by the writer (Van Cleave, 1920). It is pertinent to the present study that *C. constrictum* was the first species of the genus *Corynosoma* to provide the evidence that mutilation is responsible for the loss of genital spines of the female. All earlier investigators had assumed that the lack of these spines was normal and represented the basis for an oft cited instance of sexual dimorphism in *Corynosoma*.

The importance attached to the removal of genital spines of the female has led the writer to make a special study of the structures involved. There is great individual variability in the size of the genital spines on *C. constrictum* even when the individuals are present in the same host specimen. Figs. 4 to 7 show the genital extremity of four different individuals of *C. constrictum* all from the same specimen of the ruddy duck taken on Buckeye Lake in Ohio by Mr. Robert Rausch. On one of the individuals carrying fully formed embryos no spines were observable (Fig. 7) while on another (Fig. 6) two very minute spines could be seen. In the young individuals the spines are never in strict order of arrangement but more than 40 are observable as irregularly dispersed over each lateral surface of the genital tip (Fig. 4, a male).

A number of females have been observed (Figs. 6, 7) in which the area adjacent to the genital pore is apparently moulded into a definite globular projection by the muscular copulatory bursa of the male during copulation. The term genital papilla is applied to this structure.

In males of *C. constrictum*, an abundance of unusually well preserved material has offered a series of stages (Figs. 1–3) for the study of the male copulatory bursa rarely seen in any other species of the ACANTHOCEPHALA. In as much as the copulatory cap is an internal cast of the copulatory bursa, the cement glands and ducts associated with the bursa should all be studied together.

In one cotype individual, a freak of microtechnic resulted in complete opacity of the reservoir of the cement glands with its main duct on one side leading into the bursa and a series of radiating ducts around the periphery of the introverted bursa (Fig. 1). The other individuals of the same species had the bursa extruded in varying degrees and orientation (Figs. 2 and 3). In one of these (Fig. 2), the radiating ducts around the margin of the bursa show their position in the partially extruded bursa. The two muscular pouches (by some called Saeftigen's pouch) which surround the cirrus are shown still within the posterior end of the body. In another specimen (Fig. 3), the fully extruded bursa is shown in rather unusual orientation, in end view with the two muscular pouches lateral to the cirrus.

In the course of critical examination of all of the specimens of *Corynosoma* from

water birds in the collection of the writer, one collection of a species distinct from *C. constrictum* was encountered. This is here recognized as a new species and is described under the name *Corynosoma anatarium*.

Corynosoma anatarium, n. sp.
(Figs. 15-17)

With the characteristics of the genus *Corynosoma*. Body relatively small, lacking conspicuous enlargement of the spine-covered fore body. Genital extremity (Fig. 17) in both sexes provided with a small number of cuticular spines, irregularly scattered. Body length 4.2 to 8.6 mm, maximum diameter 0.9 to 1.7 mm. Proboscis (Figs. 15, 16) about 0.55 mm long and 0.28 to 0.29 mm in maximum diameter; armed with 14 longitudinal rows of 8 or 9 hooks each. Largest hooks approximately 0.088 mm long and 0.023 mm thick at the bend; those near the tip and base somewhat more slender; basal hooks 0.047 to 0.059 mm long and frequently not more than 0.01 mm in thickness; near the tip, 0.059 to 0.082 mm. Hard shelled embryos within body of gravid females 0.1 to 0.112 mm long and 0.02 to 0.023 mm wide, with a short, rounded polar bulge on the second membrane at each pole.

Type host: "Duck" at College Station, Texas, collected by Dr. E. W. Price.

Holotype female (VC 2131.5, Fig. 15) and 11 paratypes (all females except one male, allotype VC 2131.11, with proboscis completely introverted) in collection of H. J. Van Cleave, Urbana, Illinois.

Like *C. constrictum*, the only other species of the genus so far reported from birds of North America, the life history and intermediate hosts are wholly unknown. The two species from North American water birds are most readily distinguishable from each other on the basis of number and size of the proboscis hooks. *C. constrictum* (Figs. 11-14) has from 2 to 4 more longitudinal rows than are found in *C. anatarium* and the largest hooks in the former rarely exceed 0.047 mm in length while in the new species they are commonly 0.088 mm long. A review of all of the species of the genus seems to give evidence of rather definite differentiation of the species of the two hemispheres and fairly sharp cleavage between the normal parasites of birds and those of mammals. However, on morphological basis the new species is rather readily distinguishable from those of other regions of the earth.

C. anatarium belongs to the group of species having distinctly less than 18 longitudinal rows of proboscis hooks. Besides *C. constrictum* and *C. anatarium* this group includes the following species: *C. tunitae* reported from water birds of Africa; *C. bullosum* from marine mammals near the antarctic; *C. turbidum* from water birds of the African continent; *C. mergi* from a duck of marine habitats in Sweden; *C. phalacrocoracis* from a cormorant of Japan; *C. peposacae* from water birds of South America; and *C. pyriforme* a practically unknown species from European birds. Of the foregoing *C. turbidum* is readily distinguishable from all others by the one or a few greatly enlarged hooks on the ventral side of the proboscis. *C. tunitae* has a greatly inflated fore body which is lacking in *C. anatarium* and has a genital vestibule concealing genital spines if such are present. *C. mergi* lacks genital spines in the male and these are present in *C. anatarium*. The longitudinal rows of proboscis hooks are more numerous in *C. pyriforme* (16-18 vs. 14 in *C. anatarium*) and in *C. phalacrocoracis* (17 vs. 14 in *C. anatarium*) and the largest hooks in the latter are considerably larger than in the new species. *C. bullosum* and *C. peposacae* have distinctly more hooks on the proboscis and in the latter they are smaller than in *C. anatarium*.

From 1904, when the genus *Corynosoma* was first named and delimited, until 1918 this genus remained unrecognized in the birds of North America. The

description of *C. constrictum* from a single host species of an isolated locality in 1918 has been supplemented in the present paper by additions of other hosts and localities until after a quarter of a century the species is now recognizable as showing no necessary restrictions within the fresh water habitats of this continent and no sharply defined host limitations among the ducks inhabiting our fresh waters. There is at least the possibility that the new species here recognized as *C. anatarium*, with a single host species from a single locality, may likewise become more widely known as larger and more representative collections are studied.

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EXPLANATION OF PLATES 1 AND 2

All drawings were made with the camera lucida from stained individuals mounted in Balsam or Damar. Katharine Hill Paul, scientific artist in the Department of Zoology of the University of Illinois, made all of the illustrations.

- bursa—male copulatory bursa
 cement ducts—meridional cement ducts in bursa
 cement gl.—cement glands of male system
 cement res.—reservoir of cement glands
 gen. pap.—genital papilla of female
 gen. pore—genital pore of female
 gen. spines—genital spines, both sexes
 lem.—lemnisci
 musc. pouches—muscular pouches of male copulatory bursa
 testes—male gonads
 x—position of detail shown in Fig. 10.

PLATE 1

Details in the morphology of *Corynosoma constrictum* Van Cleave, 1918

Each entire line accompanying Figs. 1-3 has the value of 0.5 mm, all other figures on this plate are at uniform magnification with scales having value of 0.1 mm.

PLATE 1

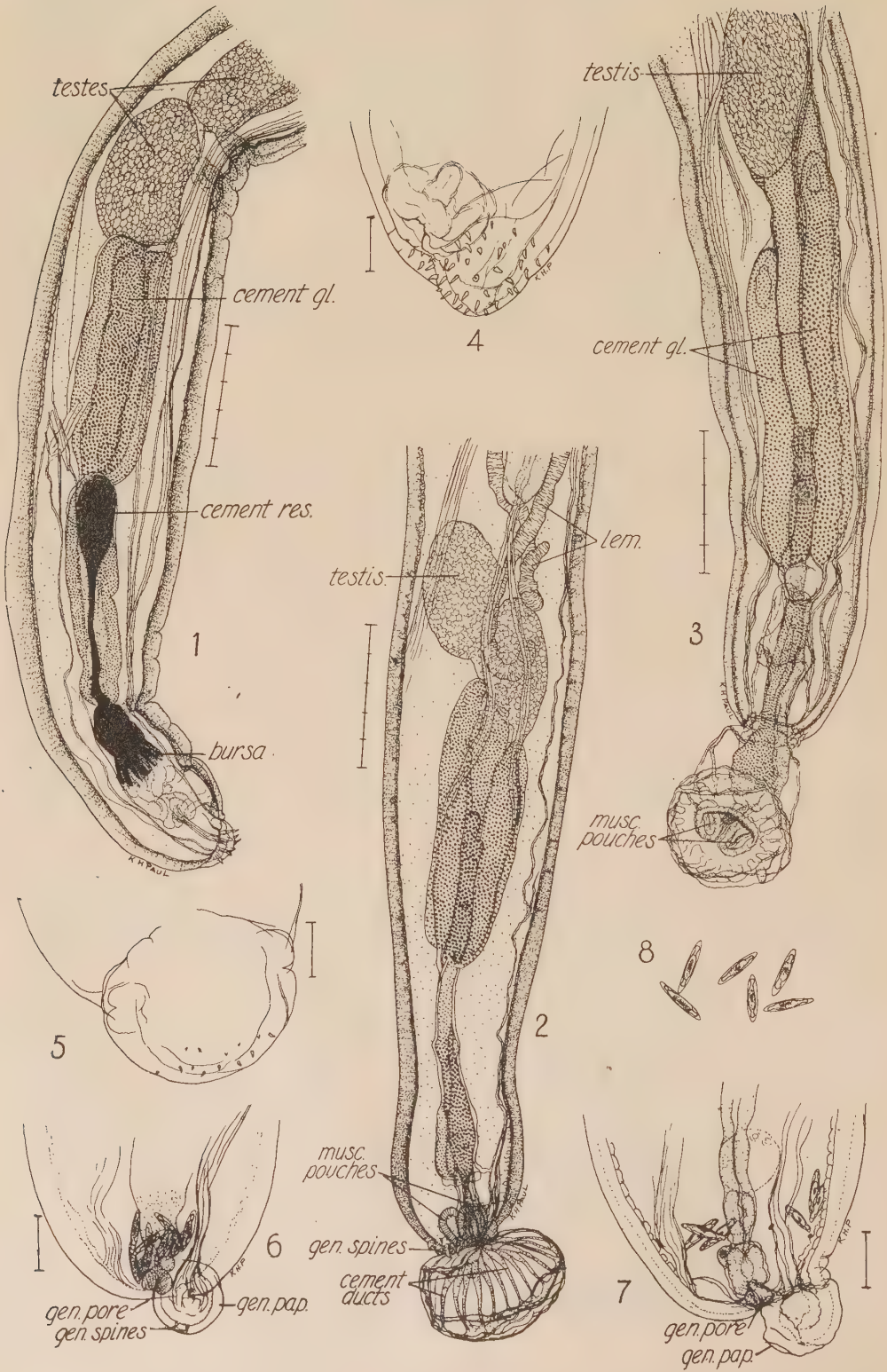


PLATE 2

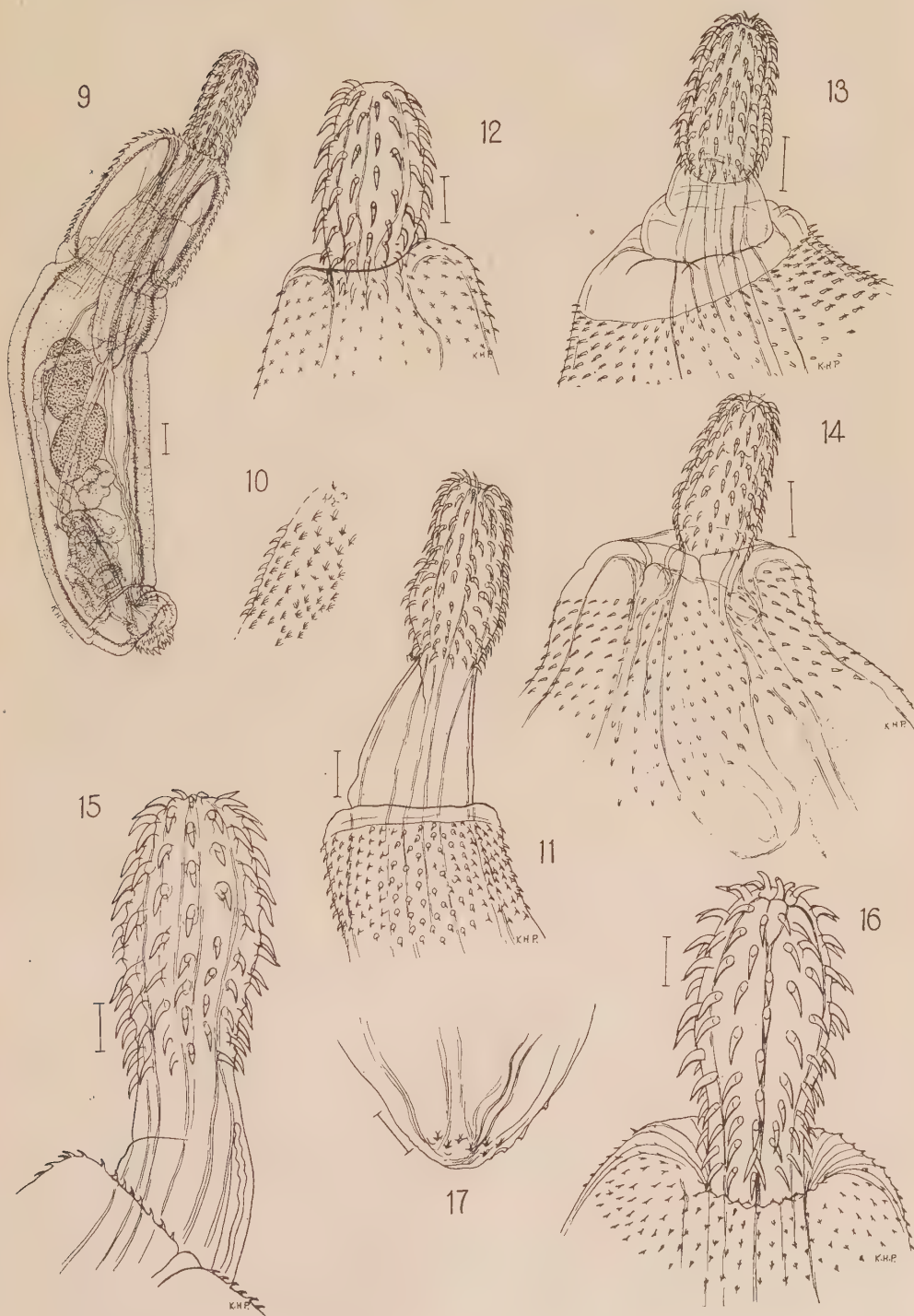


FIG. 1. Posterior end of a cotype male in which the cement reservoir and its ducts became opaque. Of the two main ducts, only the one on the right side of the body is shown. The digitiform ducts are within the margin of the bell of the introverted copulatory bursa.

FIG. 2. Posterior end of a male with copulatory bursa almost wholly extruded but with muscular pouches still within the body. Note the ducts from the cement reservoir running meridionally in the extruded bell of the bursa. Position of genital spines, anterior to the front margin of the extruded bursa, is shown.

FIG. 3. Copulatory bursa completely extroverted, in ventral view showing openings of the meridional cement ducts and the two muscular pouches lateral to the small median cirrus.

FIGS. 4-7. Posterior ends of a series of individuals from a ruddy duck (Ohio) to show sexual and individual variations in size, number and arrangement of the genital spines. •

FIG. 4. Genital spines of a male.

FIG. 5. Small, scattered genital spines of a female.

FIG. 6. A female from which all but two of the genital spines had been lost from the genital papilla.

FIG. 7. A female showing no genital spines on the genital papilla.

FIG. 8. Several mature embryos from the body cavities of two different females from the ruddy duck.

PLATE 2

Details of the morphology of *Corynosoma constrictum* Van Cleave, 1918 and *C. anatarium* n. sp.

On this plate the line beside each drawing indicates the value of 0.1 mm.

FIG. 9. A cotype of *C. constrictum* showing details of morphology. Note that body spines are omitted from the lateral surface of the fore body (their arrangement at "x" shown in Fig. 10).

FIG. 10. Detail showing shape and pattern of arrangement of spines of the fore body at region in Fig. 9 marked "x."

FIGS. 11-14. Variations in appearance of proboscis, neck, and fore body in *Corynosoma constrictum*.

FIG. 11. Proboscis, neck, and fore body fully extruded.

FIG. 12. Neck fully telescoped within fore body.

FIGS. 13 and 14. States of retraction of neck into fore body.

FIGS. 15-17. *Corynosoma anatarium* n. sp.

FIG. 15. Proboscis, neck and fore body, the latter with spine field shown in optical section, omitting the spines on the lateral surface of the body.

FIG. 16. Individual with neck entirely telescoped within fore body, the latter showing arrangement of body spines.

FIG. 17. Posterior extremity of a gravid female showing many of the genital spines intact.

A SCRUB TYPHUS (TSUTSUGAMUSHI) OUTBREAK IN DUTCH NEW GUINEA

JAMES T. GRIFFITHS, JR., CAPT. SN. C.

Little information concerning scrub typhus (tsutsugamushi fever) as it occurs in Dutch New Guinea has ever been recorded. Gunther (1940) stated that although numerous cases of scrub typhus had been noted in territories under Australian mandate, no cases had ever been reported from Dutch New Guinea. It is known, Kohls et al (1945), that in New Guinea the disease is caused by *Rickettsia orientalis*, that these organisms are found in native wild rat populations, that certain species of mites belonging to the subfamily TROMBICULINAE are vectors, and that these mites appear to prefer grassy moist areas in which to complete their development. This report is a study of an epidemic of scrub typhus which occurred among American troops during August and September of 1944 at an advanced base in Dutch New Guinea.

On 30 July 1944, elements of a United States infantry division with attached units landed on the 20-mile stretch of enemy-held coastline between Cape Sansapor and Cape Opmarai on the Vogelkop peninsula of Dutch New Guinea. The first typhus casualty became ill on 6 August. Subsequently through 30 September there were 931 cases and 34 deaths. Fig. 1 shows the number of hospital admissions per day for all troops on the base. Since daily admissions fluctuated considerably, the line showing seven-day averages presents a better history of the casualty rate. It will be noted that the outbreak reached epidemic proportions almost immediately, but that after two weeks the rate gradually decreased. By 30 September there was about one typhus casualty being admitted to the hospital per day.

RELATIONSHIP BETWEEN TYPHUS INCIDENCE AND ENVIRONMENT

Figs. 2 and 3 show the original terrain features as they existed prior to the landings. Although troops were present on both Middleburg and Amsterdam Islands, the majority of the camp installations was found between the Table and Yuma Rivers on the mainland. Additional outposts were maintained for a time at the Kor River at Cape Opmarai, and at Sansapor village. By questioning individual patients and by studying the movements of organizations on the base, it was possible to determine the geographical source for most of the typhus cases, and thus, definite relationships between the various environments and typhus incidence could be made. Four types of environments were readily distinguishable. These included abandoned native village and garden areas, overgrown coconut groves, vine-grass associations at the forest and beach margins, and climax rain forest. Each is discussed below.

Abandoned native village and garden areas.—Scattered along the entire coast were semi-cleared areas which appeared to have been either native villages, small plantation areas, or the sites of former native gardens. Coconut, banana, papaya, and kapok trees were often present, but probably exerted little or no effect upon

the ecology of the typhus mite. Grass had established itself throughout these areas. It was knee high and rank enough that the soil was shaded and remained moist except during dry weather.

More than 500 cases of scrub typhus were contracted in this type of environment. The most important typhus sources (see Figs. 2 and 3) were Mar Village (300 cases), Sansapor village (175 cases), and cleared areas in the vicinity of the Kor River and Cape Opmarai (75 cases). Although small numbers of Japanese soldiers had lived in some of these localities, there is no evidence to support a theory that their presence was in any way connected with the typhus incidence of these local areas. This environmental type definitely produced a higher incidence among the personnel involved than any other type of habitat.

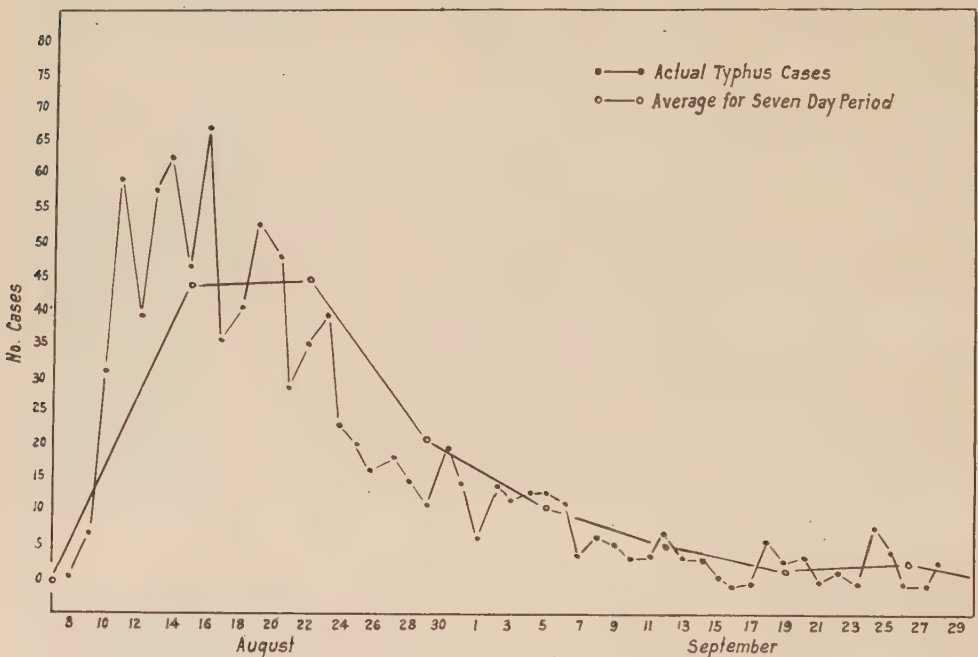


FIG. 1. Scrub typhus hospital admissions per day.

Overgrown coconut groves.—Middleburg Island was three and Amsterdam Island six miles from the mainland. Both were covered with coconut groves which had been neglected during the Japanese occupation. A dense undergrowth had arisen between the trees. This was composed largely of young coconut trees and ferns, but small amounts of grass and scrubby growth were also present. Although there was sufficient shade to maintain a moist topsoil, a low typhus incidence (21 cases on Middleburg and five cases on Amsterdam) occurred. No satisfactory explanation for this low rate can be offered at this time, but it is suggested that the lack of grass may possibly have contributed to a reduced mite population. No extensive areas of this type were present on the mainland although a small coconut grove was present at Sansapor village.

Beach and forest margins.—A strip of grass and ground-clinging vines extended along the entire beach from east of the Kor River to west of Sansapor village.

This floral association varied in width from about five to 30 yards and was found at the margin between rain forest and sandy beach. Part of it was exposed to direct sunlight during the greater part of the day and moist topsoil was maintained only where shade was furnished by forest margin trees. Although 90 cases of typhus were recorded from this environment, the incidence was low as compared with those in Mar and Sansapor villages.

Climax rain forest.—This type of environment covered most of the base. It was composed of tall trees whose interlocking branches produced a dense shade. No grass grew in the forest and the bare ground was covered only by moist rotting

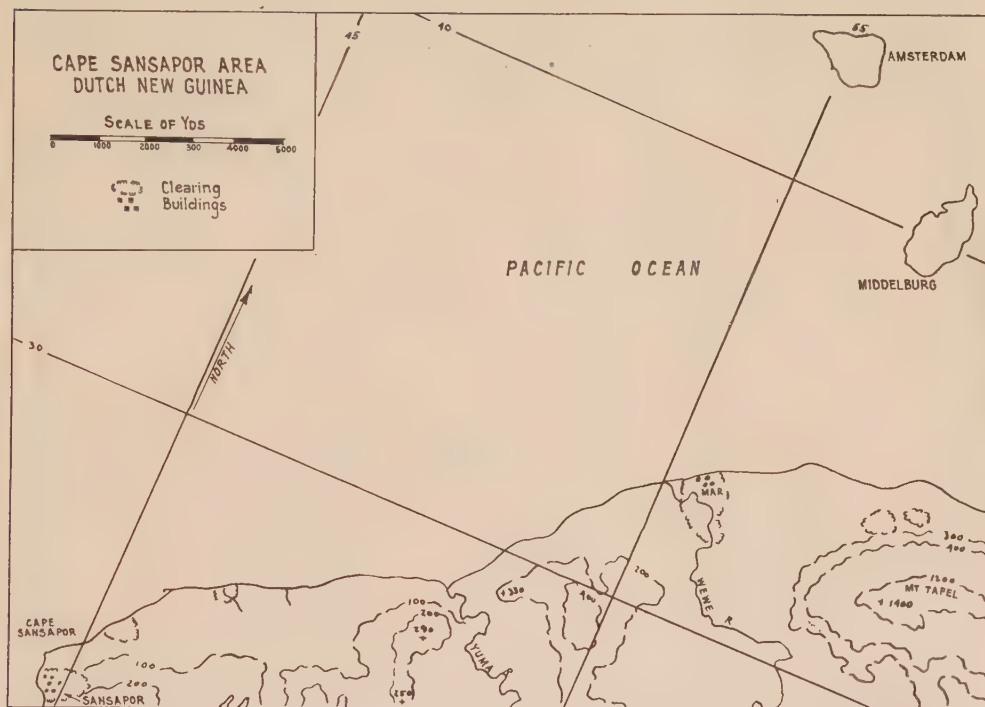


FIG. 2.

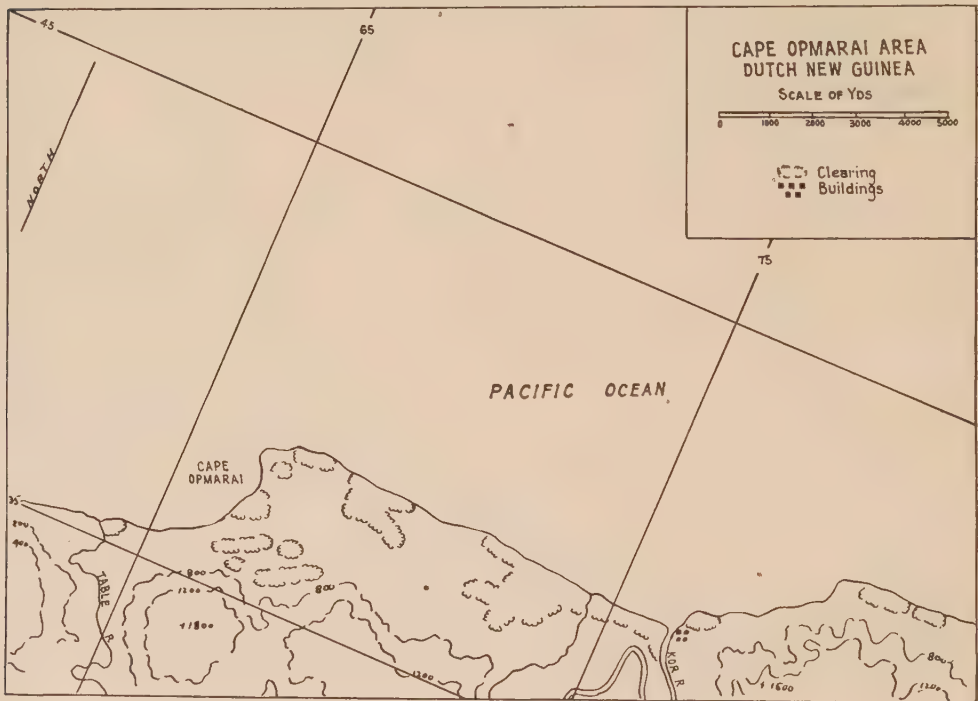
leaves. Although it was impossible to definitely trace a single case of typhus to this environment, it should be noted that scrub itch due to the bites of larval mites was a common occurrence among unprotected individuals working in virgin rain forest. In one region a road paralleled the beach and acted more or less as a boundary between the vine-grass association on one side and true rain forest on the other. Although comparable numbers of men lived on both sides of the road, only scrub itch was reported from the rain forest area, while on the beach side of the road 20 typhus cases developed. It appears reasonable to assume that rain forest was probably not a source of scrub typhus.

INCUBATION PERIOD

For this epidemic it was possible to determine from certain case histories that the typhus incubation time varied within a range of 7 to 17 days and averaged 11

days. One soldier who landed at Mar village on 30 July became ill on 6 August and was admitted to the hospital three days later. In this case, seven days represented the longest possible incubation time. Maximum periods were first suggested when it was noted that an organization usually became typhus free within 16 days after moving to a non-infectious area.

However, the most information on incubation times was obtained when the 2nd Battalion of one infantry regiment went on patrol to the Kor River. The battalion departed for the Kor River on 10 August. That night they slept on the ground in a cleared area about 500 yards west of the river. The next morning they moved up to the river and encamped on both sides of the stream. On the morning of 12



FACTORS INFLUENCING TYPHUS CONTROL

Clearing unit areas.—At the Sansapor-Opmarai base the removal of all grass and undergrowth from an infested area proved to be a practical means of typhus control. When the top soil had sufficient time to thoroughly dry out, it appeared that the area could be considered as typhus-free. In numerous instances troops unknowingly moved into infested areas. Those organizations which cleared their camp sites immediately had only a few initial cases. On the other hand, those units which failed to properly clear such infested areas suffered typhus casualties over prolonged intervals of time.

Rat control.—Since in New Guinea rats are the known animal reservoir for the rickettsiae of scrub typhus, rat control as a long range program would appear to

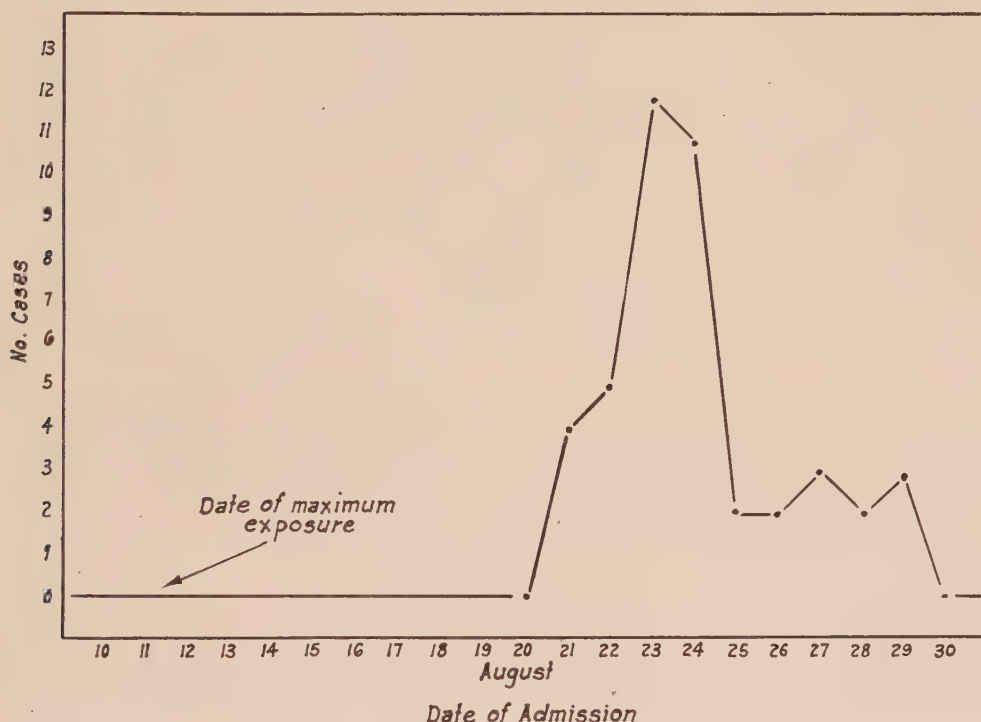


FIG. 4. Typhus incidence in 2nd Battalion.

be desirable. Although a rat control program was instituted early in this epidemic, no evidence as to its beneficial effect could be demonstrated. Under conditions prevailing in New Guinea where adjacent uninhabited areas contain large rat populations, it appears that during short-term military operations rat control does not offer a practical means for controlling scrub typhus.

Clothing treatment.—Although clearing an area represents a means of long-term control, under combat conditions protection must be obtained for those men actually engaged in combat or on patrol. Knipling and Dove (1944) state, "The most effective means of protection from chiggers (Trombiculid mites) was found to be the application of liquid repellents (dimethyl phthalate, Indalone, Rutgers 612) to clothing. Clothing can be sprayed with repellent or dipped in repellent solutions

with effective results." The modified clothing treatment developed by Captain R. C. Bushland, Sn.C., of the United States of America Typhus Commission was used after the diagnosis of scrub typhus had been made at Sansapor. This method is the impregnation of clothing with dimethyl phthalate-soap emulsion. On both Middleburg Island and the mainland, some clothing was treated as early as 4 August. However, this involved small units and cannot be considered as being instrumental in affecting the over-all typhus picture. It was not until 1 September, after supplies became available, that most of the troops were fairly consistently wearing treated clothing, and by that time between 850 and 900 cases of typhus had already been contracted. Even if clothing treatment had been generally instituted by 15 August, because of lag incubation (see Fig. 1), more than 700 casualties would have occurred. The protective value of clothing treatment, where properly used, was well demonstrated by several units. These instances are described below.

By comparing the typhus rates of the three rifle companies (I, K and L) of the 3rd Battalion of one infantry regiment, it was possible to demonstrate the beneficial effects of clothing treatment. On 31 July these companies had arrived at Sansapor village. Although Company K remained in the highly infectious Sansapor area, I and L Companies on 11 August moved to an area of low typhus incidence at the mouth of the Yuma river (see Fig. 2). Therefore, other factors being equal, it was to be expected that the admission rate for I and L Companies would fall below that for K Company. As shown in Figure 5, the exact opposite was true. At this point it should be noted that Company K had begun systematic clothing treatment on 14 August, but the other two companies did not begin treatment until more than two weeks later. As indicated on the graph, zero day represents the date of initial clothing treatment for K Company and the date of movement from Sansapor for I and L Companies. If clothing treatment were effective, typhus admissions from K Company should be reduced after zero plus 19 days. As indicated on the graph, this was exactly what happened. In contrast to the one casualty in K Company, I and L suffered 11 cases during a comparable number of days. This was in spite of the fact that K Company remained in the highly infectious Sansapor area.

It may be argued that the clearing of the Sansapor area rather than clothing impregnation was responsible for the reduction in K Company's typhus rate. However, two signal air warning units and one anti-aircraft organization had remained with K Company at Sansapor. They did not treat their clothing and they had a steady typhus rate throughout August and early September. In view of this, the conclusion appears justified that clothing treatment was the important factor in reducing the typhus incidence in K Company.

One section of beach which possessed a typical vine-grass association was occupied by seven different units on about 13 August. Table 1 lists the units in the order in which they lived on the beach, the status of clothing impregnation, the number of men in each, and the number of typhus cases. The marked contrast in typhus incidence between units wearing properly treated clothing and those not wearing such clothing is well demonstrated in this table. The organizations wearing properly treated clothing had no typhus cases as opposed to 15 per cent typhus casualties for those units without impregnated clothing. It appeared that clothing impregnation was the factor which produced this difference in the number of typhus cases.

One infantry regiment arrived at the Sansapor-Opmarai base on 23 August, 25 days after the initial landing. All men were ordered to wear treated clothing when they disembarked. The regiment moved into a beach and rain forest area

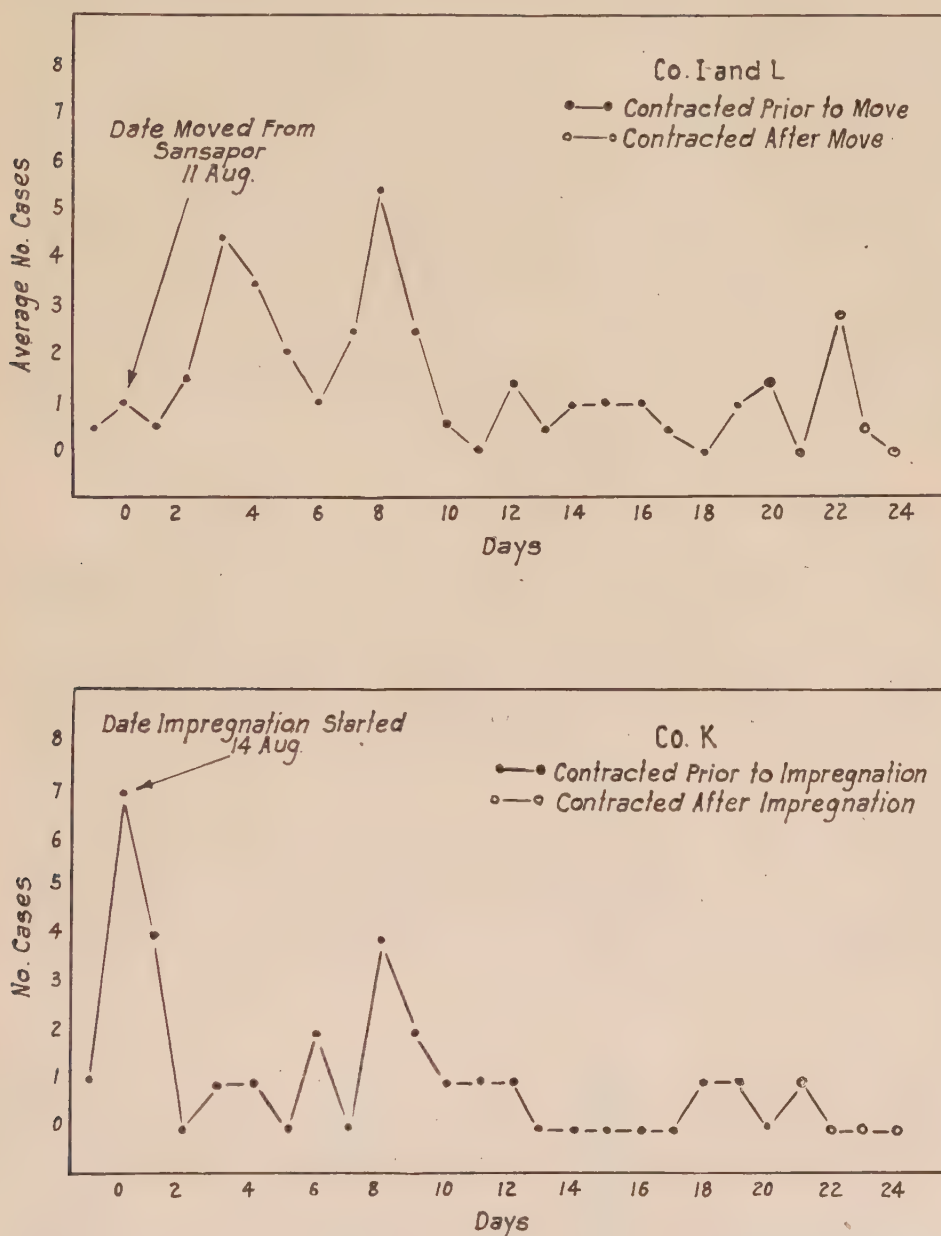


FIG. 5. Typhus cases from rifle companies of 3rd Battalion.

where it reported only two cases of typhus. These were contracted during the first week at the base and both admitted their failure to wear treated clothing during that period. Thus, an entire regiment had only two cases out of approximately 3000 men. This compares very favorably with a field artillery battalion in a similar

and adjacent area which wore no treated clothing when moving into its area and which had an incidence of three cases for 800 men.

As previously stated, the 2nd Battalion of one infantry regiment was on a patrol at the Kor River and during a three-day exposure period contracted 44 cases of typhus among about 800 men. Company I of the same regiment followed the 2nd Battalion, remained one week at the river, and contracted 16 cases among approximately 180 men. Company L replaced I Company and was in the area for seven days. However, its members wore treated clothing and they suffered only four typhus casualties. All three units engaged in similar activities and camped on essentially the same site while at the river. When they are compared on the basis of cases per man days of exposure, the rates for the 2nd Battalion and for I Company are four to five times higher than for L Company. Here again, the unit wearing impregnated clothing had a greatly reduced typhus incidence.

TABLE. 1.—*Typhus cases and status of clothing impregnation for seven units living side by side*

Organization	Status of clothing	No. men	Cases typhus
Unit	Not impregnated	15	3
Unit	Impregnated	12	0
Unit	Impregnated	13	0
Unit	Not impregnated	100	8
Unit	Not impregnated	35	12
Unit	Impregnated	36	0
Unit	Impregnated	12	0

All of the 126 men admitted to the hospital during the month of September had some opportunity to have learned about treated clothing and to have worn it. Of this group 67, or more than 50 per cent, were interviewed by the author. Only one man of the 67 had faithfully worn impregnated clothing (trousers, shirt, and socks) throughout the time of possible exposure. He gave a daily history of walking naked through 25 yards of vines and grass when going to and from ocean bathing. However, even if his case was a failure for clothing treatment, only one man in 67 represents a very low percentage.

Clothing treatment cannot be expected to result in 100 per cent control since sleeping on the ground or in fox holes, failure to wear impregnated socks, and the improper treatment of clothing will allow some break-throughs. However, on the basis of the above facts, it may be concluded that treatment will markedly decrease the number of typhus cases in infectious areas.

MEDICAL STATISTICS

In order to review the medical aspects of the situation, a letter written to the Division Surgeon by Major Robert W. Hollenhorst, M.C., is quoted. It reviews a sample of 275 cases and is in complete agreement with the findings of the other units that hospitalized typhus cases at the Sansapor-Opmarai base.

The typical initial cutaneous lesion, the eschar, was present in 92 per cent of cases, with swelling and tenderness of the local lymph glands in all cases with the eschar. The eschars were situated as follows: 24 per cent in the axillary region, 20 per cent on the scrotum, 11 per cent on the thighs, 8 per cent in the inguinal region of the abdomen, 8 per cent on the penis, 6 per cent on the back, 5 per cent on the abdomen, and 4 per cent on the arms above the elbows. There were 4 patients (2 per cent) who had lesions on the eyelids, and two patients with lesions on the neck.

Of the other symptoms manifested by these patients, the fever, general body aches, backache and eye-pain were fairly constant findings. Ninety per cent of patients had an intractable head-

ache, 3 per cent had hiccoughs of severe degree, 11 per cent had troublesome diarrhea, 30 per cent had from moderate to severe constipation, 5 per cent complained of cough, and 45 per cent had marked photophobia. Cough was a fairly frequent complication, as was a transitory deafness. Over three-fourths of these patients complained of moderate to severe insomnia.

At approximately the second day of the disease, 95 per cent of these patients developed a generalized lymphadenopathy. About the third to the sixth day of the disease, a maculo-papular rash, similar to that of measles, but located over the body and extremities, appeared in 28 per cent of these patients. This rash persisted to about the tenth to twelfth day, and seemed to have no relationship to the severity of the disease.

The fever was continuous throughout the disease, oscillating between 101 and 104 degrees daily. This fever ultimately fell by lysis in 70 per cent of the cases, and by crisis in the remainder. It was noted that those in which the fever fell by crisis had a course of much shorter duration, 11 to 16 days, and that the disease on the whole was much more mild; while in those in which the fever fell by lysis, the course of the disease was more severe, from 14 to 21 days, and was followed by a much slower convalescence and moderate to marked anemia.

This particular epidemic was characterized by a high incidence of basal brain involvement in that approximately 1 per cent of cases showed delirium, varying pupillary changes, intractable and exquisite headaches, nystagmus, and increased tendon reflexes. In one case only, stiffness of the neck muscles and positive Kernig's sign was noted. Spinal puncture was done in 12 cases, two of which showed xanthochromic fluid and moderate increase in the number of lymphocytes, but the rest of these cases had a clear fluid with a mild increase in lymphocytes. No case showed increased intraspinal pressure. All cases that died, of which there were eight, died a cerebral death, although there were signs in all cases of terminal collapse of the peripheral circulatory system with cyanosis, respiratory distress, and fall of the blood pressure.

Thirty-four deaths (3.65 per cent mortality) occurred among 931 cases of typhus. Table 2 lists the fatal cases and shows the apparent source of infection, date admitted to the hospital, date of death and (assuming two days illness prior to hospitalization) the duration of the disease prior to death.

TABLE 2.—*Typhus mortality statistics*

Source of infection	Date of hospitalization	Date of death	Days from onset to death
Undetermined	2 Sept.	11 Sept.	11
Undetermined	2 Sept.	11 Sept.	11
Mar village	13 Aug.	22 Aug.	11
Mar village	11 Aug.	20 Aug.	11
Vine-grass	12 Aug.	22 Aug.	12
Mar village	29 Aug.	8 Sept.	12
Sansapor	30 Aug.	9 Sept.	12
Sansapor	15 Aug.	25 Aug.	12
Sansapor	19 Aug.	30 Aug.	13
Sansapor	16 Aug.	27 Aug.	13
Sansapor	18 Aug.	29 Aug.	13
Vine-grass	5 Sept.	16 Sept.	13
Mar village	11 Aug.	22 Aug.	13
Undetermined	25 Sept.	6 Oct.	13
Sansapor	10 Aug.	22 Aug.	14
Undetermined	11 Aug.	23 Aug.	14
Sansapor	14 Aug.	26 Aug.	14
Sansapor	16 Aug.	28 Aug.	14
Sansapor	17 Aug.	30 Aug.	15
Mar village	21 Aug.	3 Sept.	15
Mar village	16 Aug.	30 Aug.	16
Sansapor	28 Sept.	12 Oct.	16
Vine-grass	16 Aug.	31 Aug.	17
Mar village	16 Aug.	31 Aug.	17
Sansapor	10 Aug.	25 Aug.	17
Mar village	10 Aug.	25 Aug.	17
Vine-grass	23 Aug.	8 Sept.	18
Sansapor	20 Aug.	5 Sept.	18
Sansapor	23 Aug.	10 Sept.	20
Mar village	16 Aug.	3 Sept.	20
Sansapor	13 Aug.	31 Aug.	20
Sansapor	23 Aug.	11 Sept.	21
Sansapor	16 Aug.	8 Sept.	25
Mar village	24 Aug.	17 Sept.	26

Reference to Table 2 shows that of the fatal cases 15 contracted the disease at Sansapor, 11 at Mar village, four in a vine-grass association, and four from unknown sources. It is questionable if any conclusion regarding virulence at a given

locality should be made from these data. Death occurred in from 11 to 26 days with an average of 15 days.

INCIDENCE AMONG JAPANESE TROOPS

Very little information has been acquired concerning the incidence of scrub typhus among Japanese troops in this area. One Japanese prisoner of war was admitted to the hospital in September. His condition was diagnosed as scrub typhus with initial malaria complication. He died on 25 October with typhus fever listed as the cause of death.

SUMMARY

A scrub typhus epidemic among American troops in Dutch New Guinea is described. During a 60-day period there were 931 cases with 34 deaths (3.65 per cent mortality). The various factors concerned in the relationship between environment and typhus incidence are listed and discussed. Effective methods for controlling scrub typhus under jungle conditions are suggested. Medical statistics including incubation times are provided. One case of typhus in a Japanese soldier is reported.

CONCLUSIONS

1. For this epidemic, incubation times varied from seven to 17 days and averaged 11 days.
2. Scrub typhus was associated with grassy areas or with locations that contained some type of low dense ground cover.
3. Clearing of unit areas and the wearing of properly treated clothing were effective means for controlling scrub typhus under jungle conditions.

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AMERICAN SOCIETY OF PARASITOLOGISTS

PRELIMINARY ANNOUNCEMENT OF THE TWENTIETH ANNUAL MEETING

THURSDAY TO SATURDAY, MARCH 28 TO 30, 1946
ST. LOUIS, MISSOURI

The American Society of Parasitologists will convene for a three-day program meeting in conjunction with the convention of the American Association for the Advancement of Science in St. Louis, Missouri. The sessions will be held in the Municipal Auditorium.

The program will probably be arranged as in previous years, with all of the sessions of the first and third days devoted to contributed papers. The afternoon session of the second day will be given over to papers presented by demonstration and members are urged whenever possible to present or illustrate their work in this manner since it affords greater opportunity for informal discussion than is possible at other program sessions. Papers which are read may also be presented by demonstration.

The address of the retiring President, Dr. A. C. Chandler, *THE MAKING OF A PARASITOLOGIST*, will be scheduled for 11 AM on the second day of the meeting. This will be followed by the annual luncheon and the general business meeting of the Society. Tea will be served during the afternoon demonstration program.

The call for papers will be sent to all members of the Society. Abstracts of papers to be read in person, or by title, or presented by demonstration must be in the office of the secretary by December 1, 1945. These abstracts will be printed as a supplement to the December, 1945, issue of the *Journal of Parasitology*. Members are hereby informed of the final date for submitting abstracts and are urgently requested, because of current unavoidable difficulties in publication, to be prompt in mailing their abstracts for the program.

Respectfully,

JAMES T. CULBERTSON,
Secretary

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